AN ATTEMPT TO EXPLAIN

THE NATURE

OF

ELECTRICITY,

AND

ITS INTENTION

IN THE ECONOMY OF THE UNIVERSE.

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Only two forces in Nature, due to Caloric and Electricity,—they are antagonists, the latter causing in matter a disposition to cohere, the former producing repulsion among its particles. Every atom contains both of these imponderables in a free and latent condition —to these agents substances are indebted for their bulk and weight. On the manifestation of dynamic changes in molecules or masses the Sciences of Chemistry and Natural Philosophy are based. Electricity maintains its own equilibrium by the following modes of distribution, viz: by gravitation of matter, its decomposition and re-composition; by conduction, convection, radiation, and the discharge. The imponderables originate all movements in every department of Nature. Order Heaven's first law. Vegetables and animals exist in obedience to laws imposed upon matter by the Creator. As like has an attraction for its like, so with respect to some bodies, like begets its like—greater amount of imponderables in organic than in inorganic bodies—their properties correspond and rise in importance. Growth of plants and animals attributed to the power of organized matter to attract similar materials, to alter and appropriate them. Electricity the cause of this attraction—is increased by the change of form which living matter undergoes in the system. Animal heat the result of the deposition of tissues or the change of blood from the venous to the arterial consistence; animal innervation the result of the disintegration of tissues or the change of blood from the arterial to the venous character. The imponderables contribute to health and disease in the animate part of Creation as they cause harmony and derangements in the inanimate.

WHAT IS ELECTRICITY?

PART FIRST.

Before opening this discussion let me prepare my reader for the novelty of my views by bringing to his recollection a subject of a kindred nature which has undergone the ordeal of criticism usually allotted to propositions which startle our prejudices. The phenomena of mind had been long studied before the time of Gall and Spurzheim; certain facts connected with mental operations had been received as positive truths, and yet no system had been devised in accordance with Nature until the science of Phrenology was disclosed with its simple demonstrations and undeniable evidence. Such is the predicament in which I find Electricity. Facts abound without number, but no system, no theory to connect them together, and indicate their intention in the economy of the Universe. If the now well-known phenomena of Electricity had been elicited during the prosecution of experiments instituted to prove my proposed theory instead of being quoted in its support at this late period, how different would be the result on public opinion. Electricity has been associated so long with other indefinite properties of matter or regarded as a material but imponderable fluid, that it will require an unusual

amount of evidence to overcome the force of education and habit; and yet, if my senses do not strangely mislead me, we have been overlooking an explanation of its office from very proximity, while straining our eyes to discover it afar off and clothed in profound mystery.

I at once proceed to assume certain principles, the value of which will become more evident in the course of my argument. It is necessary to take this step in limine, unless I should enter upon a dry and elaborate detail of the reasons which have prompted me to adopt them.

I shall endeavour to show that there are two primitive forces in Nature, due to Caloric and Electricity; all others being mere modifications or concomitants of their action—these imponderables are antagonist agents, and preserve the equilibrium of the Universe, the former giving to matter a property of elasticity or a centrifugal direction, the latter of gravitation or a centripetal tendency—in other words, Caloric is the cause of positive expansion and relative levity; Electricity of positive condensation and relative weight.

Every atom of simple or compound ponderable matter contains a determinate quantity of these fluids, by which its identity is maintained and most important qualities defined. This amount is constitutional and inalienable, whereas that which is subsequently attached or combined with it is only essential for its particular form or relation to other atoms, and may be assumed or given up according to circumstances.

Electricity then exists in two states, latent and free, thus resembling Caloric: it is not however really

liberated from matter, but is in such a condition as to be appreciable by our senses. When combined with Caloric it constitutes Light, and in this connection alone may become free.

The distance of one planet from another, or of a planet from the sun, or of one star from another star, is regulated not by the amount of matter, but of the imponderables aforesaid united with the masses. Their motions are attributable to actual transfers of the imponderables from one orb to another, thereby causing local derangements or an excess of a force in some section.

The disposition of Caloric and Electricity resident within our own sphere may have varied at different epochs of the Earth's history: we may suppose them to have been once diffused equably throughout its entire extent; and under these circumstances matter may have been in a semi-fluid condition. At that period, a square inch taken from the most peripheral strata would have contained as much homogeneous matter and the same proportion of the imponderables as one taken from the innermost. This state of things is now probably limited to that part of our globe which lies beneath what is called its crust.

The changes alluded to have arisen not merely from spontaneous causes possibly originating within the Earth itself, but from the same which operates on its grand movements, namely, the rays of Solar light. On separating from the Sun, a more exalted relation of atoms was substituted for the homogeneous character of its most superficial strata, and combustion ensued as a consequence of this arrangement. During

the transition the mass may have emitted a portion of its free imponderables in the shape of Light to distant worlds, as the Sun is now doing in order to reach its destined equilibrium of internal forces. The motion of the Moon is regulated by the direct rays of the Sun, also by those reflected from the Earth, just as the Earth is sensibly affected by rays from the Moon in a less degree.

The dynamic nature of atoms being different, although they might have exhibited a promiscuous intercourse under particular exigencies of time and place, they were ready, as I have before remarked, to accommodate themselves to a change of circumstances; those for instance which contained more constitutional Caloric than Electricity would be inclined to separate from the rest and from each other, while those which contained more Electricity than Caloric would take a contrary direction and keep together as close as possible. For this purpose the former must have surrendered to the latter a portion of their combined Electricity, and the latter a portion of their combined or latent Caloric to the former: so that no sudden violence is contemplated by this hypothesis, but a gradual and mutual compromise whereby have arisen the conditions necessary for the more complicated phenomena of Life.

The present state of our Earth and its relations to the Sun require that although atoms have changed places, the equilibrium of forces is not lost; that theoretically speaking, the free imponderables are still equably diffused throughout the sphere, whereas the latent imponderables vary with the particular form and

stratum of matter considered. I have said theoretically speaking, because in reality the variations of Electricity are as unceasing as those of Caloric, and to both must be attributed all the movements with which we are acquainted, whether animate or inanimate.

Matter in the abstract is inert, its leading properties essentially depending upon the imponderables. The inertia so called of an atom or congeries of atoms represents their more constant and quiescent attitude with regard to other atoms, as regulated by their respective amounts of the imponderables. Any addition or substraction might produce a change of that relation and consequent movement; not necessarily however, as may be thus shown. The Earth is attracted towards the Sun and repelled from it by its own inherent imponderable forces, and Solar light being composed of both forces adds to the amount, but in an equal ratio; consequently, no change of distance results. If the rays brought more Electricity than Caloric, the attraction would be in proportion, terrestrial weight would be temporarily augmented, and terrestrial inertia permanently altered: if Caloric prevailed, its repulsive agency would engender comparative levity, and the Earth would recede further from the Sun. The specific weight of a particular section of our planet, as contrasted with another section, causes it to move upon its own axis. With us, the inertia of bodies expresses a fact, viz: that the equilibrium of forces being once established, they would remain so, but for some disturbing cause. The only conceivable case in which a perfect equilibrium could

ever have existed was at the moment when the Earth first parted from its parent, the Sun, and presented a homogeneous mass of matter throughout. Its present condition or equipoise of ponderable and imponderable elements is due to derangements which may be referred partly, if not principally, to their external relations. Were these removed or superseded, the Earth would probably return from its quasi-artificial to its primitive but not chaotic state of Nature, as it originally obtained. This is figurative language but serves to convey a distinction, to which I attach some importance, between the more natural and the acquired dynamic constitution of the Earth, whether considered as a whole or in reference to its parts. It would be more correct to define weight as an impulse both electrical and thermal, appreciable by our senses; since it is as easy to prove the upward as the downward operation of electrical forces, without interfering with the general law upon the subject. Caloric may likewise operate in an apparently centripetal direction without really affecting its rule of action.

The above exposition of forces will, I hope, save me from the imputation of holding the Phlogiston Theory—mine is essentially different in every particular; since I acknowledge that the addition of matter however light to another portion of matter necessarily increases not only the amount of materials but also the absolute amount of Electricity, or of weight in the abstract. It however may render the mass really and specifically lighter by increasing the relative amount of Caloric, which more than counterbalances the addition of Electricity by swelling the vo-

lume. Some will contend that all particles are of equal weight, and that it is their number which renders one mass heavier than another of equal volume; but it appears to me that if they differ in weight, it is because the heavier contains more Electricity and less Caloric than the other; or, at least, that the cause is owing to the relative proportions of the imponderables.

It is self-evident that matter by some means retains consistency in opposition to a force which tends constantly to separate and disperse it. Now, a positive agent has been discovered capable of explaining repulsion, but none has been clearly assigned as the specific cause of attraction. What is the office of Electricity? Can it be regarded as matter, when it possesses not a single attribute in common with it? Philosophers will say that it obeys some of the same laws, but I propose to show that these very laws merely prove the presence of the agent, and that the attraction of aggregation and cohesion, chemical attraction, magnetic and electrical attraction, gravitation, &c., may be explained by its interposition. The admeasurement of matter was once almost the exclusive occupation of the Natural Philosopher; at the present day, the knowledge of weight is the grand object of the Chemist. To Gay Lussac belongs the merit of pointing out a new relation of atoms; his theory, however merely contemplates the fact of their combining in definite volumes, as well as definite weights. We may make allowance, it is true, for pressure; we may estimate the resultant volume of combining gases or vapour, but how far from complete our analysis of the phenomena presented, if latent Electricity is concern-

ed as well as Caloric in determining the form and specific gravity of matter. The ascertainment of bulk and weight are familiarly associated in scholastic exercises; but in the scientific enunciation of principles which should guide us, how little is it suspected that possibly Caloric and Electricity, which are as familiarly associated in our studies, may be the actual causes of relative bulk and weight. The balance or volumescope may afford us a kind of evidence that cannot be disputed; they settle many doubtful points, but as regards the ultimate constitution of matter, its dynamic qualities, its action and reaction, we obtain nothing definite. The Chemist may separate minerals into their component elements, and he may combine them again; but to do even this he must possess certain conditions of the barometer and thermometer: in other words, Caloric and Electricity are requisite in such proportions as will facilitate the proposed metamorphoses. Can he find such conditions of the imponderables for the synthesis of organic compounds?

Let us suppose that each atom of matter is composed of a specific radical, with properties modified by the presence of Caloric and Electricity, which from their opposite qualities may hold different positions; Caloric residing, as it were, on one terminus of a spheroid molecule, and Electricity on the other. A congeries of atoms in which Caloric predominates over Electricity would by their readiness to separate possess a larger capacity for free Caloric than for Electricity, and vice versâ the argument holds good with those in which Electricity prevails over its rival. It is however so ordained, that by mutual concessions

such atoms although very discordant may harmonize together, and on these changes the sciences of Chemistry and Mechanical Philosophy are based. Their original constitution gives them a tendency to return to their more congenial form, but their actual capacity for both, and capability of combinations with each other, enable them to hold communion together.

Electricity may be studied with reference to the modes in which it distributes itself or finds its equilibrium, viz: by gravitation of matter, its decomposition and recomposition; by conduction, convection, radiation, and the discharge. By the term gravitation we may understand the phenomenon of matter approaching matter by a force proportionate to their respective shares of Electricity. The heaviest bodies are those in which Electricity abounds in the greatest degree, so that the metals are most recommended for obtaining quantity. The Earth gravitates towards the Sun by reason of this agent, and its rotation may be thus explained. The equable distribution of the free imponderables on the presenting surface is deranged by the torrents of Light emanating from the Sun; the polar inclinations and declinations being amenable to the same influence. The peripheral strata possessing a larger capacity for the calorific portion of the rays than those more remote, the balance is lost; and whilst repulsion is produced by the Caloric accumulated on the presenting hemisphere, both the diurnal and semi-annual changes are enforced by the relative excess of Electricity on the distal hemisphere, which therefore is attracted by, and gravitates towards, the Sun's orb. The attraction exerted between

distant worlds is simple and absolute, for the intervening space allows the imponderables full scope for the exercise of their functions; but when this force is brought to bear upon particles or masses not regarded in space, but as forming a part of a connected system of contiguous molecules, there arises a necessity of submitting to counteraction from the particles or masses within a certain range—hence we find that other laws must be studied, to explain other processes of electrical equilibrium. One of the most interesting is the mode in which excess of matter dissolved or suspended in air during its expansion in summer is forced to find its level when the cause of its elevation no longer operates to the same extent, and consequently there is an error loci to be remedied. While the masses are precipitating and collecting mid-air, they are enabled to detain much of the electrical rays which would otherwise reach the ground and be lost in its wide extent: they are surcharged with a descending force, and whether cloud or meteor, make a violent effort to seek a refuge from their now unnatural height. At a certain distance however from the surface they are stopped perhaps in their career, either by the compressed air below them, or by the attenuated gases which are confined and expanded in their midst by the latent Caloric evolved. The sudden shock causes the Electricity to come to a focus and to be discharged, the cloud is dissipated either in part or whole with explosion, and it descends in the form of rain, which aids in conducting the electric fluid to the ground. Here is an instance in which the gravitation of matter is aided by positive additions of

free Electricity; in which Electricity itself maintains its own equilibrium when *e situ* either from accident or design, as in the usual experiments of the laboratory. The Earth's crust is ever willing to receive it into its bosom, being equally ready to give up free Caloric. The atmosphere presents reversed phenomena, so that while we must look to the solid crust for the most obvious effects of internal heat, we recognize electrical disorders most prevalent in the air. The Ocean seems to be neutral; in it both play their part with less chance for exhibitions of a marked character. And why is this? Because the air is a bad conductor of Electricity and the Earth's crust of Caloric, whereas the Ocean may receive considerable additions or subtractions without very manifest disturbance: such is the singular dynamic constitution of liquids and water in particular. The rotation of the Earth on its axis would be attended with accelerations and retardations but for this power of the Ocean to accommodate itself to the difference of absorption and conduction of Light between solids and liquids.

All substances in changing their form give out or receive one or other of the two imponderables mentioned—thus, when iron is heated, it is continually absorbing free Caloric, until the point is attained at which the free Electricity present is unable to resist the expanding force of the Caloric, and at this conjuncture a definite portion of Caloric combines with the molecules which now become liquid. I use the term definite in a restricted sense, for the amount depends upon varying circumstances, and the case therefore somewhat differs from the definite chemical com-

binations of Authors; but the relation between the one given out and the other absorbed is constantly maintained and fixed by definite laws. Again: were it possible to aerify the metal the same thing would occur. When vapour escapes from the steam engine, the boiler if isolated becomes charged: this arises probably from the sudden change of form which the vapour sustains, like the materials emitted from active volcanoes, which develope Electricity in great abundance. A salt dissolved in water may rob the solvent of a portion of its Caloric, but it at the same time parts with some of its own Electricity to balance accounts. The intention of all such changes, whether chemical or mechanical, is to produce as easily as possible a dynamic equilibrium, which is the main object of creation, and from which there is not a single departure. If heterogeneous materials are brought into juxtaposition some kind of arrangement must be made between them: it may be slow and imperceptible, or rapid and violent; but action and reaction supervene, as effects of a universal cause. The electric fluid may be conducted like Caloric from one atom or congeries of atoms to another, or it may be conveyed by the same to a resting place, as may best suit the occasion. I should here observe that, for convenience, I shall use the term temperament to express for Electricity what temperature does for Caloric, viz: the imponderable in a free state. If, then, two different metals of the same temperament and temperature—in other words, at the same barometrical and thermometrical point—be simultaneously exposed to a change of circumstances, not having the same ca-

pacity for the imponderables and being in contact they are differently affected; so that if they be heated or cooled or moved from one medium into another, their relation to each other and the medium will be altered. Thermo-electric experiments prove that free Caloric is capable of disturbing Electricity as free Electricity developes Caloric in the galvanic apparatus. I would direct especial attention to the solidification of a drop of water, if it be placed on the junction of two differently conducting metals and exposed to the voltaic current in a certain direction: on changing the poles, its ebullition ensues. This phenomenon may arise from a difference of rapidity in the electrical current causing a difference of temperature, since analogous effects are derived from coils and twists, not to mention inequalities and interruptions in the connecting wire of a voltaic series, which necessarily impede or expedite the current at certain intervals of the circuit; but it may happen that in this instance the Electricity, set in motion by Caloric, combines with the drop. The Glacial Theory of Professor Agassiz is not weakened, to say the least, by admitting the power of Electricity to solidify by its presence, as of Caloric to do the same by its absence. Let a plate of copper and another of zinc be immersed in acidulated water; the zinc possessing a less capacity for Electricity than copper parts with a portion of its free Electricity, which is instantaneously conducted from one to the other, thus enabling the copper to resist more successfully oxydizement, while the zinc is left less protected than before. When the fluid is in great abundance, its passage is indicated by

a condensation of the molecules constituting the conducting medium with the extrication of Caloric to such an extent as to melt or burn the wire as a secondary result. The particles of the zinc surface, being separated by a loss of Electricity as if by the addition of positive Caloric, are enabled to unite with the oxygen of the water; they become more nearly allied in dynamic constitution to oxygen, under the circumstances, than is oxygen to hydrogen. I am far from meaning to say that the nearer substances approximate in their imponderable relations the greater energy is evinced in their reactions, but that *cæteris paribus* they will harmonize better together; less chemical violence is necessary for their combination, and less liability exists of explosion or divellent affinities. The peculiarity of decomposition in the voltaic apparatus consists in the happy mode of turning the free Electricity to account, instead of allowing it to pass away unheeded as in ordinary cases of chemical union. The copper acts as a catalytic agent, which, by its presence, influences the result. When cases of double elective affinity occur and the excitement of all the poles is neutralized, the only effect worthy of mention is, that equivalent products are obtained in each cell and a more natural relation substituted between the conflicting materials. In these cases quantity of Electricity is obtained, in others of a mechanical nature the fluid is notable for its quality or intensity. How can we account for the influence of some fluxes but by supposing that electrical conduction is no less important than that of Caloric in chemical processes which are allied. I can discover no

difference between the Caloric imparted by conduction to contiguous particles of tallow, which are decomposed and volatilized during the combustion of a candle, and the gradual developement and conduction of Electricity from particle to particle during fermentation or digestion. Liebig ascribes the phenomenon to motion produced by the ferment on matter which admits a similar metamorphosis of atoms, and the explanation is in keeping with the modern doctrine that some bodies are easily converted from one form to another by a mysterious change of polarization; but it appears to me that the loss or gain of the electric fluid will suffice for this and other chemical phenomena of the same kind.

When heterogenous materials are subjected to friction in bad conducting media they receive or give up a portion of their free Electricity according to their respective capacities. This is an expedient on the part of Nature to counteract sudden violence, to arrest its progress, and lastly, to attain relief. If a metal be rubbed in the open air or in vacuo, it depends upon the electrical nature of the rubber whether it obtain a surcharge or deficiency of the fluid. Under ordinary circumstances the equilibrium would be instantaneously restored; but let us suppose that the metal remain positively excited, the air in its neighbourhood is induced negatively in order to rob it gradually of the excess: let the plate of metal be now approximated to that body which is more notably deficient by reason of previous attrition, and if the charge be sufficiently powerful and the distance not too great the fluid concentrates at some point, and

by its accumulation constringes the intervening aerial particles so as to form a continuous line for its passage to the negative surface. The forcible condensation of those particles causes the spark, which is different for different media. When instead of air glass is the electric employed, the fluid will sometimes select a convenient spot on which to exert its energies and procure a passage from one surface to the other by constringing a certain number of molecules, which being elastic subsequently recoil and are dissipated like vapour. Let it be observed that I use the terms *positive* and *positively induced* differently; the former denoting simply a redundancy of the electric fluid, which must find its equilibrium somewhere sooner or later in conformity with laws which cannot be controverted: but the latter is restricted to media of a certain kind, in which a peculiar method of relief is in request, such as I have before adverted to. If I might be allowed to speculate upon the actual process, I should hesitate between two probable modes. There may be a common apex to two pyramidal cones, induced in an electric; for instance, in the case of a cloud, the presenting surface is subtended by the base of a reversed aerial pyramid negatively induced, the apex of which either reaches or is not far distant from the apex of another aerial pyramid positively induced, and resting on the ground which forms the base of a reversed pyramidal space under ground negatively induced. This type admits of variation and accounts for diverse appearances which lightning exhibits when instead of one several spaces and surfaces are concerned; so that one apparent discharge may

be resolved into as many as the case requires. The other mode I would suggest is the rotatory movement of particles, so that in the cloud itself a tendency of the kind exists, which is sympathetically felt by the air between it and the ground. The direction of the intervening particles being centripetal, at length a line is formed sufficiently dense to conduct the fluid from one surface to the other. In the case of a charged pane of glass, it is the difficulty of forming the pyramidal figure or rotatory movement of particles which retains the fluid so tenaciously on its surface.

I will here introduce for consideration some phenomena which fortify the position I have assumed as to the real nature of Electricity. During the formation of a thunder-cloud, when the crisis is near at hand, there is a stillness and suffocating dryness of the air, and at this conjuncture drops of water are deposited very freely on the leaves of plants which are negatively charged, and we may suppose a similar condensation to occur in the direction of the positive cloud. It may be said that the rarefaction of the air renders it unable to hold up so much vapour, and that this is really another expression of dew. This admission is all I require at present, for the accumulation of such facts in connection with a deranged state of the electrical fluid will be collateral evidence in my favour. I will venture further, and ask whether the induction set up in this and other instances is not an abortive or rather a vain attempt at chemical combination; whether there is not sometimes a minor degree of attraction exerted which falls short of its proposed object: the extraordinary power which po-

rous substances evince for fluids would indicate a kind of electrical induction or condensation akin to it. Mr. Cross, by passing a small constant stream of Electricity through water, detached the calcareous and silicious particles dissolved in it, and set in motion the vital machinery of some infusorial animalcules. Instances without number might be adduced in which the condensing power of Electricity is apparent; such as the formation of crystals at the negative pole of the galvanic circuit; and the solidification of Glauber's salts on the admission of common air into a bottle in which the salt has been previously dissolved by water heated and allowed to cool. Dr. Ure, I believe, attributes this last phenomenon to Electricity, without however attaching any definite idea to the function of that fluid as the antagonist of Caloric.

Radiation is the last mode of distribution and is of two kinds, simple and compound. Pure electrical radiation takes place when there isan excess of the fluid which escapes diffusively by constringing the medium of its passage. Whether the concomitant light is produced by the condensation of gases or of solids the phenomenon is identical; but their capacity for Caloric being different, metals will give out Caloric whereas gases instantly reabsorb it, so that in the so-called vacua no indications of Caloric appear. Glass or ice are better electrics than water or dense air, these again than thin vapour or rarefied gases for obvious reasons. There is certainly more Caloric in rarefied air than in air at the usual atmospheric tension, but, notwithstanding, the Caloric offers less resistance to electrical

condensation in the one than in the other, because there is a negative condition of Electricity in the former which does not exist in the latter. A perfect vacuum I believe would be a perfect nonconductor, whereas compound radiation in which Electricity is combined with Caloric passes readily through a vacuum. Through some media Light passes without much change except in intensity, by others it is almost immediately reflected or absorbed with total loss of characteristic qualities. Its reflection depends upon the condition of the surface; its refraction or decomposition upon the physical and dynamical state of the surface and mass. Red rays give up most readily their Caloric and are least refrangible, the violet yield their Electricity and are most bent from the perpendicular: thus further demonstrating the tendency of one set to converge, of another to diverge according to their dynamic constitution. Light is modified by substances identical in ponderable materials but dynamical dissimilar. The appearance of carbon is proverbially varied, and that of pure glass is also remarkable for the same diversity and other physical properties. The most intense artificial light is produced on lime by the oxy-hydrogen flame. This alkaline earth is so composed that when its temperature is raised by the combustion of the gases, it rapidly seizes the vapour formed, and both are dissipated with great developement of heat and electricity. But how can either imponderable pass off through such a bad conductor as lime? The only resource is radiation. Vast mineral forests of fuel lie buried in the bowels of the Earth; these are treasures of Electricity as well as Caloric. We

do not usually receive more than half its worth by the use of coal in stoves: even the rays of light which reach us from open fires are by no means to be considered as representing the extent to which Electricity is available. As might be expected, the combination of gases does not produce so much Light as when solids and gases are employed.

Magnetism might be appropriately introduced here as a branch of the subject, and a difficulty which must be met. I shall dismiss it summarily. Let us suppose a force such as that of Solar Electricity to be constantly operating on the Earth a revolving mass, and we will add disadvantageously operating if not counteracted at all points. Let us further suppose that this extraneous force comes in conflict with the permanent Electricity of the Earth, and that as a general law one current always sets another in motion at right angles: that this second current manifests itself either by the gyratory movement of the imponderable fluid itself, or by that of ponderable matter, and we have but to assume that certain materials possess a dynamic constitution which renders them particularly sensitive to electrical impressions, and Magnetism stands out in bold relief another expedient in the Economy of the Universe. It is a collateral force dependent and consequent upon a prior force in action, and by its rotatory movement tends or proposes to neutralize a direct and positive interference whether from abroad or at home. It silently but efficiently equalizes the derangement of equilibrium in a manner inconsistent with the defined duties of Caloric, and as far as the Earth en masse is concerned, from quarters (North and South) beyond the

province of Caloric as an efficient Antagonist in the balance of power. If artificial currents of Electricity generate counter-currents of a magnetic character, so it may be presumed that artificial or natural currents of ponderable matter will do the same, whether it be to remedy a thermal or electrical deficiency or derangement. According to theory we ought to find some phenomena of magnetism in the human body, and we hear of experiments by which needles are rendered magnetic by their insertion near the course of the motor nerves. It may appear frivolous to notice the method which is occasionally adopted in the West, when the object is to discover a subterranean spring or running water at no great depth. The process is extended to the pursuit of metallic veins, and I need scarcely mention that it is extremely simple; viz, to balance a switch in a certain manner until it makes a revolution apparently accidental. A priori we might suppose that motion of any kind would impress its condition upon any sensitive or good-conducting matter in its vicinity, and more especially upon matter which is equipoised and liable to be swayed by the slightest influence of a dynamic kind. It remains to be proved whether more careful experiments will substantiate the claim of these results to philosophical truths.

The laws then which govern the imponderables are few and simple. We may speculate upon individual phenomena and be foiled in our explanation, but we may rest assured that the object which Nature strives to attain, is Order.

PART SECOND.

I HAVE stated that the essential requisite for decomposition and recomposition is a want of harmony between the imponderables present in contiguous particles of matter, whereby mutual concessions are made, just as the phenomena of gravitation depend upon a disturbed equilibrium between those Agents in particles or masses, when a mere change of position will answer the purpose of an equilibrium. An aggregation of identical or nearly similarly constituted molecules will occur, as of isomorphous salts, by a natural adaptation and affinity without what may be styled chemical reaction; that is, there is no need of much if any compromise of Electricity on the part of one, or of Caloric on the part of the other; but a mechanical adhesion takes place corresponding with their own inherent capacities for the imponderables. In chemical reactions a third party assists materially the process, and water is a very common medium in which such opposite substances as gases and solids are enabled to act and react on each other with great rapidity and success. An acid will perhaps not combine with a base for which it is thought to have a strong affinity—Why? Because there is so wide a difference between their imponderable conditions as to preclude a union. Let water be now added which will allow the acid or base to form a solution more in accordance with the nature of the base or acid, and a

salt is formed. Oil will not combine with litharge until water is added because the quasi-salts oleate and margarate of the oxide of glyceryl composing the oil possess too much latent Caloric to admit any reciprocal action of a chemical nature in favour of a base so much at variance as the oxide of lead: but let this difference be somewhat reconciled by the presence of water which by uniting with the oxide of glyceryl enables the fatty acids to take the metallic base. So the soluble chlorides before they are dissolved first assume the middle state of chloro-hydrates, which condition is known to exist in such compounds as the chloro-hydrates of quinia, morphia, &c. The oxide of ethyl or even the hydrate of the oxide may fail to dissolve an organic substance, but an aqueous solution of the hydrate may be adequate for the purpose. The oxide of an alkaline metal is not so effectual a solvent as the hydrate of the same, much less than an aqueous solution of the hydrate. In fact water or any liquid which admits miscibility to an apparently indefinite extent is in the same category with what is usually called free caloric: but, strictly speaking, there is a minor degree of chemical union between such substances, one more easily deranged and less obvious and defined as the combining ~~qualities~~ require a wider range of time and space for their settlement. To make these calculations we necessarily recur to the relation between the constitutional nature of the materials in question and the free imponderables in which they are immersed without reference to any immediate connection between the materials themselves. By these means I am enabled to dispose of

Dalton's hypothesis with respect to aeriform fluids, they may appear to act as vacua to each other, but a more extended view of the subject might suggest an ultimate arrangement between their particles strictly coinciding with the laws of definite proportions. Chlorine will not leave its connection with hydrogen in chlorohydric acid to combine with a metal such as zinc, but will readily embrace ammonium in a state of vapour; nor will it unite rapidly with iron unless minutely pulverized. If a stick of phosphorus and the flowers of sulphur be placed in contact under a bell-glass, on removing the air vapours of the negative sulphur will combine with the phosphorus which offers less resistance for reasons assigned. Half a volume of oxygen will not unite with a whole volume of hydrogen under all circumstances: it depends upon the state of the barometer and thermometer, in other words, on the relative condensation or expansion of the gases; as when an electric spark is passed through the mixture; or a hot iron, whereby the expansion of some particles condenses others; or when the hydrogen collects upon bright metallic surfaces as well as in the pores of certain bodies. Oxygen will refuse to combine with zinc unless the metal be positively calorified or negatively electrified; or unless the oxygen be compressed into the consistence of a liquid: their condition being now altered combination ensues. Nascent hydrogen is known to be peculiarly efficacious in its reactions; but is it not here a liquid or perhaps a solid? Does it still retain its latent Electricity which enables it to effect what it could not do after exchanging its electricity for Caloric? The pro-

tosulphide of iron is formed whether the vapour of sulphur be presented to cold solid iron in a finely divided state or whether the metal be white-hot at the welding point and the sulphur concrete.

The mechanical admixture of fluid substances is regulated by their dynamic qualifications, so that even gases are not exempt from the general rule. The presumed law of their equable expansion and contraction by equal increments or decrements of heat is I admit in direct opposition to the doctrine which I have propounded relating to the variable amount of constitutional and acquired imponderables present in every species of atom. "If" says an accomplished American chemist, "gases expand or contract 1-480th of the volume they occupy at the freezing point for every alteration of temperature equal to one degree, it is obvious that a given volume of any gas at 32 deg. will be expanded by a volume equal to itself by having its temperature raised 480 deg. but at this rate a given volume of any gas at 32 deg. if cooled down to 480 deg. would be contracted by a volume equal to itself, that is, reduced to nothing." Besides; the volume of certain gases does not decrease in the ratio of the increase of force used to compress them: which is an evidence in favour of their possessing a different capacity for Electricity, as the first objection sets the question at rest as far as Caloric is concerned.

The idea of an equal ratio of force from equivalent proportions of combining elements is an error I conceive into which Liebig has fallen: for although the negative of this proposition has not been proved on my part, neither has the affirmative on his—if my sugges-

tion as to the variable proportions of the imponderables be correct, neither Caloric nor Electricity will answer to the rule. Liebig states that 8 pounds of oxygen will produce the same effect as $35\frac{1}{2}$ pounds of chlorine—what effect? I answer, the same amount of base will be neutralized. Liebig cannot affirm that the same amount of Caloric is supplied or Electricity put in motion. This would argue an identity of dynamic constituents which is disproved by the unequal volume, and weight of the materials; for if it be conceded that the free imponderables are equal, might not the combined or constitutional imponderables differ? The most that can be averred is that the same amount of Electricity in motion invariably liberates identical amounts of substances which differ in volume and weight. "The numbers" says Liebig "representing chemical equivalents express very general ratios of effects corresponding for all bodies all the actions they are capable of producing. If we should assume that the quantity of force is unequal in the case of zinc with reference to its Caloric or Electricity evolved by chemical action, that for instance we had obtained double or triple the amount in the galvanic pile, or that in this mode of generating force less loss is sustained, we must still recollect the equivalent of zinc as compared with coal in order to estimate their relative economy. By a certain measure of Electricity we produce a corresponding proportion of heat or of magnetic power. A given amount of affinity produces an equivalent of Electricity in the same manner as on the other hand we decompose equivalents of chemical compounds by

a definite measure of Electricity." Again Liebig states that "in whatever way carbon may combine with oxygen the act of combination is accompanied by the disengagement of heat. It is indifferent whether this combination takes place rapidly or slowly, at a high or low temperature, the amount of heat liberated is a constant quantity." These conclusions are specious but not warranted by facts on which we can rely: their object is to place Caloric and Electricity in the same category with ponderable matter. For my own part, I can discover no analogy between them, but am ready to admit that both imponderables are concerned, and am anxious to discover how far the especial province of each may extend.

A mathematical illustration will perhaps render my views on the ultimate constitution of matter more intelligible. A radical atom A may contain one proportion of each imponderable: another and different radical atom B one proportion of each or two proportions of each: again another C three proportions of each, or three hundred, nay three thousand. But an atom of matter may possess one proportion of Caloric and two, three, or a thousand of Electricity; and we may vary the amount ad infinitum to represent its constitutional nature. What still further burthens the calculation is the capacity of each for the free imponderables according to their dynamic constitution; so that an atom M containing fifty proportions of each imponderable necessary for its identification, possesses a greater capacity for both in a free state than A which contains only one proportion of each. P containing one proportion of Caloric and five

of Electricity has a greater capacity for the latter than for the former, while X containing one proportion of Electricity and five of Caloric is the reverse of P. I need not extend the exposition of this hypothesis; it is almost self-evident, and will account for the diversity of chemical reagents. Two or more substances may contain the same elements in the same proportion and yet possess different physical properties such as density, odour, taste, colour, refraction and polarization of light; so that by the addition or subtraction of either imponderable what are termed isomeric bodies may present diametrically opposite qualities. But the term is obviously inappropriate, since iron with a certain proportion of the imponderables will act like platinum as the positive plate of a voltaic series, and with another proportion may be a substitute for the zinc. They are not therefore isomerically constituted as far as the imponderables are concerned.

Great stress has been laid upon that remarkable property of acids by which they characterize under different circumstances of their own formation a monobasic a bibasic or a tribasic salt. Phosphorus in union with five equivalents of oxygen will form very different salts according to the electrical and thermal state of the acid, as I am disposed to think; but this is not more remarkable than the fact that phosphorus itself will combine with various equivalents of oxygen under different dynamic conditions. It appears that a compound substance when once formed retains a character of its own, by which it regulates its conduct toward other bodies; that is to say, its equivalent number from that moment is com-

paratively constant and upon the proportion of its combined imponderables will depend its capacity for the same in a free state. Phosphorus under the joint influence of the imponderables in a certain amount will take one or two or five equivalents of oxygen—or perhaps it is the oxygen which in this case undergoes the dynamic variation alluded to. Are we sure that five atoms of oxygen combine with one of phosphorus to form phosphoric acid? May not one atom of oxygen assume the volume and weight corresponding to the supposed equivalent number, so that in all chemical combinations no more than one atom combines with one atom, but that this atom may be modified by the imponderables in such a way as to vary in its physical qualities according to the dose? Let oxygen for example represent an atom of matter united with a definite amount of the imponderables, by which it acquires a fixed weight and volume—the law may be, that such an atom can only combine chemically with doses of the imponderables equivalent to its constitutional or dynamic nature; it may consequently be doubled or tripled in volume and its weight likewise affected in the same ratio. But I merely throw out these suggestions en passant.

Electricity is a positive Agent as is Caloric; the comparative absence of either merely gives the other a temporary predominance of function. Atoms may assume the solid condition by a reduction of temperature, but although it may be the withdrawal of free Caloric which is the proximate cause of solidification, it is the presence of latent Electricity which is the predisposing cause. Although the absence of pressure

or subtraction of Electricity may cause solids to become fluids, yet it is the positive agency of Caloric which expands the particles. Any one of the imponderables may or may not displace its rival, so that Caloric may be evolved under the influence of an electrical excess, as may Electricity under the prœpotency of Caloric. Let us suppose however a case in which the one may be retained in spite of the other. A fulminating powder is supposed to contain gaseous atoms highly condensed by means of Electricity; when it is suddenly struck with a hammer, the electric fluid is conducted away, and the gases left to their own resources expand explosively.

Pressure like movement is of two kinds, and expresses a force in operation, whereas inertia as I have before remarked expresses its quiescence. As a general rule the diverging rays of thermal force represent centrifugal pressure, the converging rays of electrical force represent centripetal pressure. Particles are affected laterally by the imponderables resident in contiguous matter. I contend that if I press with my hand forcibly upon a solid or a fluid, I am adding so much Electricity at the expense of the materials constituting my body, and am unconsciously perhaps changing the imponderable relation which subsists in the earth upon which I stand. A bent glass tube in which gases are reduced to fluids by their own expansive force or by reduction of temperature, as well as the powerfully compressing machines of the early experimenters, illustrate the same influence but in different modes. Liebig in his late letters on Chemistry uses the following language. "Adhesion or hetero-

geneous attraction has lately acquired by the discovery of the solidification of carbonic acid gas a more extended meaning and will account for the absorption of gases by porous bodies and their condensation upon solid surfaces. It had never before been thought of, says he, that this heterogeneous attraction was the cause of change of state in matter, but it is now evident that a gas adheres by the same force which condenses it into a liquid." He thus remains contented with mere words to explain isolated facts without having realized the existence of agents capable of originating such phenomena. I have given my reasons for believing that matter may contain variable quantities of the imponderables even under the same form, so that it is not astonishing that metals should exhibit different appearances and physical qualities when solidified under different circumstances, they may form crystals or amorphous masses or a dark powder. Their surfaces when polished reflect light and are indifferent conductors of Caloric and Electricity, whereas striated or uneven surfaces absorb the same with avidity. It has been considered strange that no artificial pressure can give platinum sponge the same specific gravity as that which results from fusion. The cause appears to me to be the obstinacy with which the confined air adheres to the metal, and the difficulty which it finds in making its escape; or, the oxygen may partially combine with it. This I suspect is the case during the congelation of ice by reduction of temperature in the open air. Could pure water be artificially solidified by compression I have very little doubt but that its specific gravity would be material-

ly altered. As far as single crystals are concerned there can be no question about their combining every qualification of extreme solidity and specific gravity: it is only when the crystals are confused and interstices left which contain a partial vacuum or vapour, that we can explain the anomaly of bodies being lighter when solid than fluid, and floating on the same. Pure alumina is no longer thought to be condensable by heat.

It is so apparently simple a mode of explanation to attribute a host of phenomena to the pressure of the atmosphere that I almost hesitate to question so cherished a principle of physics. When a bullet of lead has been cut into halves which are afterwards made to cohere by a slight manœuvre, there are apparently three distinct causes of this result. First, there is an attraction between particles of an identical nature, and this in proportion to their solidity: secondly, the surfaces are rendered uneven by the twist given them in the hand, but become fitted to each other by an adaptation of the inequalities produced: and, thirdly, the air is said to press upon both pieces. To me it appears that the constitutional electricity of the atoms operate in the first and second instances to keep the particles and masses together, and that their free electricity, which likewise comes into play, depends for its amount upon the free electricity of the circumambient air; so that to whatever extent the latter be condensed or rarefied, to that extent will free electricity or a compressing power be added or diminished in the particles or congeries of particles experimented upon. Besides, in proportion as free electricity is removed

artificially from the sphere of action will free caloric be enabled to exert its authority; so that for a time the atoms composing the masses will measurably be separated by it from each other, and the two pieces themselves be less disposed to adhere. When however the attenuated air has conducted away the excess of free caloric in the bullet, its atoms begin to contract again within their former limits. It is obvious that this experiment may be viewed in two aspects, and suit two explanations of which but one can be rigidly exact. Most persons will insist upon the material particles themselves as a cause of the phenomena, others will incline with me to regard the particles inactive, but the imponderables associated with them as the agents.

A solid body suspended from a height and permitted to drop possesses not merely its own inherent share of latent and free electricity, but so much additional free electricity as the strata of air through which it falls will surrender by conduction, and its own capacity will allow it to accept on its passage. This may reconcile the problem of terresterial attraction with atmospheric pressure, if my premises be correct; for it matters not in what direction electrical or thermal deficiencies or excesses may offer; whether upwards or downwards, horizontally or diagonally, the imponderables operate, either by themselves or in connection with matter, in demanding a balance of power. Hence all matter under similar circumstances of position will eventually obtain an equal temperament, i e, an adequate supply of electrical fluid; but this consummation our senses do not realize any more than they appreciate a like temperature in bodies of

different capacity for Caloric, and conducting power. A fundamental axiom with me is the following—that change as we may the relation of the imponderables to matter within areas of a certain extent, the principle of compensation holds good, and the sum total of those agents in the said areas will always be the same, however misplaced naturally or artificially. The computation has reference to geographical as well as arithmetical ratios; but due allowance must be made for the space considered, whether it be a theoretical plenum abstracted from surrounding influences, or a part and parcel of the general mass as it exists in nature. If we take into consideration the amount of free caloric and electricity cotained in equal columns of matter extending from the level of the ocean to the uppermost bounds of the atmosphere, we shall find that there is precisely the same amount, although the matter constituting these columns may be very diversified. Thus, one column may be composed entirely of air, and will extend perhaps about fifty miles; another may consist of a portion of solid matter as of a mountain, and the remainder of air; a third will contain several feet of water and the residue of air; a fourth, of thirty inches of mercury, a very rarefied mercurial atmosphere, and the top of the barometical tube, surmounted by common air. In each and all I contend there are equal amounts of the free imponderables, although very differently distributed; and there seems to be a constant effort on the part of nature to restore to their pristine level and condition the materials which have assumed this uneven and heterogeneous character: but on the other hand, as if to thwart her

own apparent intention, the growth of vegetation, the ingenuity of man and other animals, the internal and external commotion kept up between contending elements of matter as well as the continual shifting of the free imponderables or at least their influence from one side of the globe to the other causing its diurnal and annual revolutions, all redound to beauty, variety and a wholesome change on the face of the earth. —Moreover it may be a question, whether or not the actual presence of solids and liquids in the lower atmosphere as well as the condensation of liquids and gases in the upper crust of the earth, do not realize the gradual blending of one department into the other and the establishment of a general rule. We find the resistance of the air less than that of water or iron because under the circumstances it more readily gives up its Electricity than they do; the latter having a greater capacity for the free fluid and far more of it combined with them. I will venture further and suggest, that possibly as much solid matter is either evaporated suspended or dissolved as gaseous matter is absorbed condensed or combined; and that as much positive weight is added thereby to the atmosphere as there is a loss of specific weight sustained in the crust by the addition of gases, the balance being held by the ocean which keeps up a communion between both parties. It is difficult I confess to convey as distinct an impression on the mind in favour of an equal distribution of Electricity as of Caloric in a horizontal direction. The thermometer indicates to us the same temperature; but will the barometer inform us of the equable temperament in solids, liquids and

gases under similar circumstances? Not so; because it cannot be so favourably applied. Let us draw an imaginary zone of three feet thickness and three feet width extending around the earth in any parallel of the equator; and let this zone be supposed to be fifty feet below the level of the ocean. Now it may be, that this zone would include water, a portion of the Earth's crust, and atmospheric air in some inland valley or artificial excavation. I argue, that the amount of pressure in this zone taken collectively would precisely answer to the quantity of a similar zone in the same parallel of latitude on the other side of the equator, whether it consisted of water or earth singly or combined. Like the supposed columns before considered the electrical fluid and matter would be differently distributed, and consequently the barometer if applicable, might be expected to indicate difference of pressure; but in fact, though the barometer advises us when electric changes are in progress, what those changes are deponent sayeth not, being itself subject to their influence. If we rise high in air, the barometer will exhibit a loss in Caloric and the absorption of free Electricity which the air is very willing to give up: if we descend low in the earth, the thermometer will also exhibit a similar phenomenon, viz, a loss of Electricity and the absorption of Caloric which the solid crust is very ready to yield. So that no definite knowledge is attained further than the mere fact. In the case of the supposed zone, if in any portion of it a plus condition exists, a minus might be confidently assumed in another quarter to preserve the balance; and in localities where surfaces are more

particularly exposed to these opposite influences, decomposition and recomposition would be likely to occur as well as other phenomena of an electrical character. We must suppose that either valleys exist on the surface of the crust sufficiently extensive to counterpoise, if I may be excused the paradox, the elevations above the level of the ocean, or that the difference must be made up by a temporary provision of the free imponderables of which the barometer is unable to give us satisfactory intelligence; but the proof of such a gradual return to a general equilibrium is afforded by the abrasion and disappearance of continents, although land may reappear above water in other regions by artificial means or volcanic action. Some might add the subsidence of the ocean in the polar latitudes, and the rise of the same under and near the equator. In the process of time a greater proportion of water may be dissolved in air as the crust increases in depth and the atmosphere extends its limits, in order to keep pace with the march of events below. Not that the atmosphere will be denser, but as more space will be allotted with constant additions of Caloric, more matter will be dissolved or held in suspension. It is not the amount of matter but the relative quantity of Electricity and Caloric which determines the specific gravity and specific heat of the atmosphere, which at remote periods of time may have been rather vaporous than aeriform, so that much of the iron found massive or stratified on the Earth's surface may have been held up in it as well as the Ocean, and gradually or suddenly deposited by electrical and thermal changes. I may be asked why such metals

as iron nickel cobalt manganese &c. are found dissolved or suspended in air while the lighter metals are not discovered. I am disposed to think that the latter do also there exist in minute quantities; but it strikes me that the peculiar nature of the alkalies and alkaline earths in which Caloric predominates, and that of the heavier metals in which Electricity is in the ascendant, would alike render the presence of both classes questionable. Iron nickel &c. are nearly equipoised in dynamic constitution as is water, but more highly charged than water with both the imponderables, hence it happens that great license of time and place is allowed them. I would be understood to mean that during the formation of metallic concretions, the alkaline metals would be more likely consumed and re-dissolved, so as not to form a part or parcel of falling meteors, whereas the magnetic metals mentioned, although their more difficult solubility requires a wider separation of their atoms, are enabled suddenly to converge towards the point in which there is a partial electrical vacuum with greater chance of avoiding the fate of their comrades the alkalies. It has often surprised me that any Chemist has ventured to assert positively what is the actual constitution of the atmosphere: he may fearlessly aver what he has found, but what he has not found may exist there notwithstanding his skill in analysis. I would rather believe the fact from seeing aerolites fall, and explain the presence of solid matter in minute quantities by reason of the vast amount of gases in which they are mixed or dissolved, than rely upon the puny efforts of experimentalists. A square mile of hydrogen or at least that

space in air might dissolve or contain an atom or atoms of copper which might defy our optic nerves however armed with microscopic appliances, or our hands furnished with the most delicate tests. At this period of advanced Science we are not so easily startled or confounded by the minuteness of Nature's operations: the day has passed when the grand and the imposing claimed almost universal homage. Nor are we confined in our explanations of phenomena to single modes of action—because the pulverisation of the subsoil or rock is the most obvious mode of accounting for the regeneration of the alkalies in land which has been exhausted, it is no reason why in similar lands allowed to remain fallow and exposed to the vicissitudes of the atmosphere the soil may not gradually receive additions of the fixed as well as volatile alkalies from the regions above as from the regions below—why if saline incrustations are found in various parts of the Earth to coat the surface and impregnate its layers an occasional precipitation of said matters may not co-operate with more frequent sublimations or evaporations and consequent efflorescence.

By hydrometers or gravimeters we may estimate the comparative not the actual density of liquids and solids; so it is with the thermometer and barometer in reference to their functions. The air for instance may be plus Caloric and minus Electricity; the thermometer will rise and the barometer fall. Again it may be plus Electricity and minus Caloric, and the reverse takes place. Let there be minus Caloric and minus Electricity, the thermometer now falls and the

barometer likewise: or plus Caloric and plus Electricity, the thermometer rises as well as the barometer. Such irregularities and sudden changes may produce certain forms of disease by the shock which they must make on the nervous system, independently of other causes which no doubt at such times would exist, as organic and inorganic effluvia. For this reason if the atmosphere be minus Electricity with reference to our bodies, there is a loss of Electricity on our part by conduction convection &c. which is manifested by low spirits and debility usually attributed to other causes which no doubt co-operate. When however the air seems tense clear and comparatively dry as is generally the case in some parts of Italy, where distant objects are distinctly reflected and the vibrations of air rapidly reach the ear, the skin becomes easily electrified, and the fluid accumulates on its surface, so that the friction of flannel or silk will elicit sparks of light. It is not however solely the electrical tone of the atmosphere but its material condition which regulates the retention or loss of the fluid generated within us: for it must constantly be borne in mind that any portion of matter whether gaseous or solid is negative when it has less Electricity than its share as compared with similar portions of matter, other things being equal. If it be admitted that during storms and tornadoes there is, according to Mr. Espy, a simultaneous movement of aerial currents towards a central point in which a partial vacuum exists, and that in such situations the air has become rarefied and consequently rises in vertical columns, the theory may receive additional support by supposing not only posi-

tive Caloric a cause but more frequently a negative condition of Electricity.

It is difficult perhaps to conceive how a particle or mass of matter can contain opposite qualities such as an inherent tendency to approach and fly from other particles and masses:—but sueh forces can be rigorously calculated, and by the admission of a new agent in physics, or rather an agent with new qualifications, satisfactorily accounted for. Heat and cold are correlative terms denoting simply the presence or absence of a required amount of free Caloric: resistance or non-resistance of bodies are so likewise, and designate the presence or absence of a certain amount of free Electricity. Levity results from the relative proportion of those agents in a combined or free state: weight results from the same cause. I thus explain the weight of iridium or of hydrogen, and the peculiar character of iron nickel and cobalt which seem to contain a large and nearly equal proportion of each. Potassium sodium carbon silicon and others would evince a large proportion of Electricity, but a still larger of Caloric, giving them in certain contingencies hardness without corresponding weight. Gold or the other ductile and malleable metals may have much Caloric in their composition to which they are indebted for their properties and still more Electricity which gives them great weight. But it is needless to enter into details while engaged in the consideration of great principles.

How then does the philosophy of Mechanics stand affected? What becomes of the lever of the wedge of hydrostatic and hydraulic forces? The power in

all depends upon the modifications of electrical determination and energy; upon the rapidity of conduction concentration and the alternate or mutual co-operation of the imponderables. Indeed all movements whether animate or inanimate may be traced to these all pervading Spirits: and as a case in point I shall briefly refer to some experiments made to establish the close connection if not identity of the causes which contribute to the effect. A bean during the season of germination is known to be influenced in the direction of its roots by gravity; and in proof of what this force is, or rather in proof of the fact that the same cause, whatever it is, operates in mechanical and vital movements, let the bean be appended to a vertical wheel which is rotated rapidly and for a length of time. The radicle instead of tending towards the centre of the earth or the axis of the wheel, now seeks the peripheral portion while the plumula points towards the axis. The conjoined effects of gravity and the apparently centrifugal action of Electricity may be further demonstrated by a horizontal wheel in motion, when the radicle grows downwards, and outwards. At different periods in the revolution there is a different disposal of the electrical fluid: it is not until the wheel has attained its greatest velocity that the maximum of force is found to prevail. At this crisis, if the consistency of the peripheral portion be at all liable to inequalities of action or electrical capacity, small sections may become detached with violence, and will aid materially in carrying off the superfluous fluid, or the whole may burst with like effect. The deviation thus given to the electrical fluid is a circuitous

and feasible route instead of a strait and impracticable course towards attaining an equilibrium or correcting a physical evil, if we may so regard it. It also proves that the sphere of electrical tension may be seemingly independent for the time of the grand centre of the Earth, or even of the still grander centre of the Sun: but at the same time while threatening to oppose Nature's laws, it really obeys them and keeps within legitimate bounds. The shifting of this imponderable is shown by any falling body. The whole weight may be concentrated on the proximal point which strikes the ground, a corresponding loss of weight being sustained by the distal extremity. I thus account for the facility with which direction is given to a body in motion by a slight touch on either extremity which may contain the imponderables in excess or in defect: and I presume the tendency of many solid bodies to burn in atmospheric air would be much greater on the distal than the proximal superficies in consequence of the greater resistance to the action of oxygen on one side than on the other: but as if to counteract this result a partial vacuum is formed on the rear, whilst the air in advance is condensed and proportionally energetic.

There is an extraordinary property of liquids to feel impressions which are not perceptible in a like degree by solids and aeriform fluids. Liquids contain the imponderables more nearly balanced and in a comparatively greater amount than other forms of matter, save that of animal and vegetable textures. A force applied to them is not conducted through and lost in the Earth, as is the case with most solids by reason of their cohesive compactness, nor spent as it were in

vain, as through gases by reason of their elastic and yielding nature, but it is felt in every direction, and with a proportionate intensity. The increase and diminution of volume in liquids is inconsiderable, but this is amply compensated by an obstinacy of resistance and endurance of effect. The tides are a sublime exemplification of the power which water possesses to accommodate itself to the imponderable relations between our Earth and the Sun or Moon; and the swollen waves of the Ocean speak a language which may be understood when clouds overshadow the great deep as with a pall. If pressure be made upon the open end of a vessel filled with water, the impression is transmitted through every drop—the distal layers become negative and expand the periphery as the proximal layers are condensed and become positive.

Extremes are said to meet and to neutralize each other: it is a proverb equally applicable to every modification of force in action; teaching us the policy of temperance in all things, and that excesses whether in the physical or moral world like violent diseases can only be reached by remedies as violent, and thus thwarted in their dangerous tendencies.

PART THIRD.

The felicitous relation between solids liquids and gases on the crustaceous surface of our globe as well as the reactions between the free imponderables themselves which there necessarily take place to a far greater extent than in any other portion, are calculated for a more complex arrangement between particles of matter. Hence appeared the varieties of plants and animals, which are enabled to derive sustenance from both mineralized and non-mineralized substances, and combine within themselves the requisites for growth and reproduction. As in a block of marble just taken from the quarry the sculptured form of a future figure is not as lawyers might say *in esse* but *in posse*, so we may conceive the germ of animated beings to contain rudiments of what may under favourable circumstances be developed in full perfection. The organs follow each other in succession as the imponderable influences are exerted upon matter previously organized. The modern views on Phytogeny and Embryogeny require no more than this, that all the epiphenomena are effects of antecedent causes; but they fail to point out how the forces operate or what those forces are, their direction and intention. The mystery of the vital force diminishes if rightly considered with reference to the general laws imposed upon matter by the Creator of the Universe. The

laws themselves evince infinite wisdom, but their application falls within our scope of observation and enquiry. The wonder is, not that things are as they are, but that they should happen otherwise under existing circumstances.

The ingenious reference of Man's existence on Earth his size and physical power to the relation which subsists between the weights of their respective masses has been lately advanced by Mathematicians and Physiologists, and confirms me in my peculiar views: it is another instance of what appears to me an approximative truth, but not being the whole truth is deficient in the length and breadth of its import. I hazard no opinion as to what conjuncture of events or what concurrence of atoms first gave a start to this or that vegetable or animal; it is sufficient to assume that such a phenomenon occurred. There is no necessity for appealing to a special interposition of the Deity. The germ whether considered the result of a cause no longer operating as a creative power, or the product of ordinary fructification, possesses that inherent complexity of ponderable and imponderable elements which entitles it not only to a separate entity but to the privilege of reproducing its kind. To borrow a chemical phrase, the equivalent number or dynamic constitution of such a combination of atoms must be high, notwithstanding which, it obeys the simple law regulating all matter, that "like has an attraction for its like and," as regards some bodies, "begets its like."

In studying this department of Nature we shall find that animate bodies comport with inanimate so far as they are intended to fill a place corresponding with

their imponderable composition, and that they supply along with liquids per se that space in creation which would otherwise present too sudden a departure from one extreme to another. This classification of objects so different may seem primâ facie ridiculous, unless we compare the case with another which is analogous. 2 bears the same relation to 2 that 2 millions do to 2 millions—they come within the same category of isomerism and isomorphism without partaking of those particulars which might render them identical. Thus I regard the existence of vegetables and animals as supplementary to the Ocean, and forming a part of that grand division of compound atoms which possess a middle capacity for the imponderables, and as necessarily originating from an adaptation of means to a proposed end—universal harmony. The blood is not the life of animals, but, like the succus nutritivus of vegetables, contributes to their vitality. They have water for their basis or solvent, and contain in a complicated form representatives from the three natural divisions of atoms, solids liquids and gases. These here meet on neutral ground, their peculiar characteristics and wide differences being temporarily suspended for the purpose of building up new forms and structures with sensibilities and faculties as varied. The most ready and regular channel for the introduction of oxygen into the blood is through the lungs, but this gas is also condensed upon and within the epidermis and thence absorbed by combining with the oxide of iron while carbonic acid is liberated; and thus new life is as it were imparted to the returning blood with demonstrations of greater venous activity. So like-

wise the oxygen of the air may fulfil to a certain extent the same indication in the stomach, and wherever it finds access. In ruminating animals this is particularly necessary, for the paunch is frequently overloaded and fatigued with carbonaceous matters which require time and labour for their preparation. I doubt however whether nitrogen gains admittance in this way; the conservative or tonic energies of the organ, as well as the dynamic qualifications of the gas itself would seem to prevent its combination with the constituents of the blood. Not even does hydrogen its most constant friend appear disposed to attract it; the formation of ammonia being uncongenial with the progressive changes of nutrition in animals, but rather like carbonic acid a product of retrograde action.

I am aware that when we find in the blood or sap certain compounds ready formed, we have but to assume that they are attracted by similar molecules already organized, and that they are then deposited in contact, or fill perhaps a void left by other molecules which have been removed. During the warmth of spring and summer there is, as far as Caloric is concerned, a quasi-positive state in the vessels of plants which enables the sap to descend and precipitate fresh matter within and about the relaxed parts. The same principle holds good in growing animals except that at all seasons more or less a proper exercise of the functions produces the state alluded to, by which their size is increased and consequent susceptibility of action. In fact, as I shall hereafter explain, there is a co-operation of causes diametrically oppo-

site, since both imponderables play their appropriate part in the vital drama.

An animal tissue may absorb albumen whether of vegetable or animal origin, and by a process within the body this albumen may be converted into fibrin by a very simple change of atoms, or it may be precipitated as albumen and form an organized part of the animal frame. But how is brain formed, a substance so dissimilar from every thing absorbed per vias naturales? How is albumen formed originally in the vegetable? It may be said that even this is but a trifling change from certain semi-organic compounds which the higher order of vegetables can appropriate: but it is definitely settled that they can create albumen from inorganic substances, and that this is generally the case. What other opinion can we draw, but that both the animal and vegetable possess a formative faculty in themselves, besides appropriating compounds which approximate them in constitution. It may be added that the energy of growth and perfection of structure may be enhanced by artificial supplies of congeneric materials, but there undoubtedly exists the vis creatrix as well, and it is this force which is peculiar to each tissue or combination of tissues and organs. It is well known that mould acts as nutriment to vegetables, that they live upon themselves as do animals: that this humus, as it is sometimes called, hold a middle rank like bile between organic and inorganic matter—both substances being produced or modified by the presence of acids and alkalies which act as vehicles for their absorption when dissolved in water. Vegetative life does not entirely depend upon this re-

source, but is greatly aided thereby; although en passant I may remark that humic acid consists of decayed organic matter, as does choleic acid; that vegetable mould contains matters which have been rejected from the economy as noxious or in excess—the same may be said of the products of the liver. But while it is admitted to be a general rule that the semi-organic compost arises from the decomposition or eremacausis of organized tissues, it does not follow that none could under any other circumstances have been formed. The probability is, that until a considerable quantity had been produced by purely chemical means, no very marked progress had been made in the vegetable world. According to the disposition of the imponderables upon the Earth's surface at different epochs has been the disposal of inorganic and organizable matter: the latter has increased with the lapse of ages, more especially by the munificent addition of imponderable elements derived from the Sun, the promoter if not the giver of Life. This opinion of the Sun was entertained by the Ancients, who pretended that the vital spark had been stolen from Heaven by Prometheus. We may conclude then that while vegetables and animals augment in number, the materials for their sustenance and propagation keep pace with them.

The natural tendency of a vital cell is to produce other cells by its own inherent power, and but for causes operating disadvantageously or distracting this power, the bulk of the living being would be constantly enlarging. If I am correct in attributing so much importance to Caloric and Electricity in modifying the character of organic and inorganic matter, it would

not be stretching the argument too far to consider that the organs of animals are strengthened by a proper exercise of their functions; because the nervous fluid concentrated therein attracts fresh matter to be deposited: but that if unduly worked they necessarily lose their conservative energies and are either absorbed or consumed. It is when diminished resistance is offered by a cell or tissue to the chemical influence of decomposing agents that carbonic acid and other effete matters are evolved from this source. The decay of the aged tree, the ripening of its fruit, &c. are attended by the extrication of oxidized compounds, nitrogenized or not as the case may be. An abraded surface which absorbs the oxygen of the air speedily engenders a barrier to the further intrusion of the gas in excess by a partial removal of tissue which leaves the subjacent layers firmer, more animalized and more capable of appropriating fresh matter from the blood: but if there be an ulcer in a patient with a bad constitution, however much the oxygen may wear away exposed parts, the Electricity locally developed is not sufficiently seconded by the materials of the circulating fluid to counteract corrosion, and there are no limits to decomposition.

The body of an adult supplied abundantly with food may neither increase nor diminish in weight during twenty-four hours, and moreover the quantity of oxy gen absorbed in that period must be very considerable. The explanation I would furnish is, that these new materials have been partly used for the purpose of affording him nervous excitement; in other words, of eliminating free Electricity. Had however his physi-

cal exertions been out of proportion to the amount of the ingesta, the deficiency of Electricity required for corporeal movements would have been made up at the expense of some of his tissues, particularly his fat and cellular substance, and he would have lost weight. I cannot too strongly insist, that as it is the presence of latent Electricity or the tone of a part which offers resistance to the action of oxygen and of the absorbents, and in conjunction with free Electricity attracts fresh matter, so it is the want of a normal condition or the absence of a proper share of free and latent Electricity which enables the oxygen to commit its ravages; the effect being analogous to the solution of the zinc plate in the voltaic trough while the copper is fortified by the transfer of free Electricity to it from the zinc. When an organ is paralysed or but little used, it diminishes in bulk and utility; the absorbents prey upon some portions, and chemical agents are engaged in decomposing others for the sustenance of the more efficient members. During sleep the voluntary organs are in repose and very gradually recover their size if diminished by exercise on the previous day; but the chief part of the blood returns directly from the capillary arteries into capillary veins which seem to inosculate for the express purpose of facilitating the current when not required for nutrition or function. It is at night that the involuntary offices are incessantly and almost exclusively exerted with the effect of strengthening the organs concerned, notwithstanding diminished vigour in the circulation by an altered state of the atmosphere and the absence of Solar rays.

Let my reader mark the difference which a muscle

exhibits under different aspects. When living and in possession of its dynamic powers it is tough and unyielding; when removed from the body after the animal has been butchered, the organ still retains much of its original tenacity and irritability but has lost that which the motor ganglion of the spinal marrow and the general motor ganglion of the brain could alone impart by continuity of nervous filaments. As it is now unsupported by foreign aid, it gradually succumbs to dynamic influences which surround it and are intent upon its ruin. Whilst thus imperceptibly parting with its free Electricity and Caloric, it holds its share of the combined imponderables up to the moment when it is decomposed or at least metamorphosed in the direction of decay. As long as the muscular fibre retains its proteinized character, it is itself wholesome meat, could it be separated from foreign matter which sooner undergoes the process of disorganization and by its intimate connection with the fibres separates them and renders the flesh more acceptable to the epicure or dyspeptic. As a proof that it is a subsidiary force which renders the muscle tough or the blood firm and fibrinous, let us test the fluids and tissues generally of animals which have been long driven and at length fall dead from exhaustion. Their substance is materially altered, the muscles are flabby and cannot be made to contract by irritation; the blood does not coagulate. The carcase rapidly putrefies as if it had been deprived of vitality by lightning which in its passage had left a wreck of matter behind, or as if a sedative poison had done its work. The Chemistry of Life is entirely at fault; we almost cease to recognize its parting steps.

A muscle may be excited by a local cause such as inflammation or irritation in the part itself; it may be excited by a similar condition in the spinal ganglion supplying it with motor power; again, it may be excited by a similar condition of that part of the brain which produces voluntary movement. In all and each the effect is attributable to chemical action whereby compound materials are resolved into simpler combinations either in the circulation or by transformation of tissues. The over-worked muscle or nervous ganglion becomes weaker and weaker not only by a decrease of the circulating materials calculated to evolve free electricity (particularly if food be not adequately provided,) but also by a diminution of the organ itself which requires actual reparation of parts before it can regain its wonted strenth. Impressions are made on any of the sentient surfaces of the body; among these I include the nervous expansions of general sensation, of tact, of smell, of audition, of vision, of taste, and all those which form the periphery of the brain and represent by their exercise the will. They are all I repeat organs of special sensation, and are connected with ganglia which produce motion, in other words generate electricity. For this purpose the gauglia abound in arterial vessels not merely for nutritiou but for an especial function. Those which respond to the ordinary nerves of sensation are found in the spinal column: those which correspond with the organs of mind and express volition are in the centre of the cerebral mass, viz, the thalami nervorum opticorum and corpora striata, which are continuous with the ganglia

of motion in the chord. Liebig lays most stress on calorification, the summum bonum of some Medical Practitioners: I would uphold the claims of Electricity or electrification upon especial notice without disparagement to Caloric which is concerned in chemico-vital reactions and is indispensable for our comfort and protection. His " elements of respiration" par excellence are my elements of innervation, although the supply of caloric during the conversion of albumen into fibrin and other obvious changes in the blood occasioned by the oxygen inhaled is conceded to be auxiliary without detriment to my main proposition. But I may be asked, do not animals run about in cold weather to keep themselves warm, and are not children predisposed to muscular exercise? I answer, yes—they thereby circulate more rapidly arterial blood through the extreme tissues; for by using the limbs more venous blood is propelled into the left auricle of the heart and lungs, which consequently are excited to increased action. But, do not children crave abundant and wholesome food, the appropriation of which enables them to run about and prompts them to exercise by adding to the substance of their muscles, and by stimulating the same to action? The stiffness of limbs and inaptitude for exertion which is sometimes exhibited during a very severe winter, I may also add the sleep of vegetables and the general torpor at that period, are due to the want of free Caloric and Electricity such as the Sun alone can impart in sufficient quantity. They are compelled to rely upon their own resources, and if the constitution of an animal be weak and his alimenta-

tion inadequate, his health sensibly declines for the same reason that deaths are more frequent during the night. "The abstraction of heat" says Liebig "must be viewed as quite equivalent to a diminution of the vital energy." Why then, if it is the Sun's heat which is so potent in invigorating our frames, may not an artificial temperature produce the like effects during darkness? The pure cold of winter is not disadvantageous to health, provided the rays of the Sun, comparatively few and feeble though they be, are beaming upon our countenances, and the system has been gradually prepared for the changes of season. There appear to be two sources of Electricity and Caloric in the body, independently of that which is common to all substances in the same circumstances of position on the surface of the Earth's crust. When matter is consolidated or rendered more consistent latent caloric is evolved and is taken up to an equal degree in the adult by matter which is dissolved or removed as effete: its disintegration and solution liberates latent Electricity which is received by fresh matter precipitated or deposited in situ. In this way the tone and integrity of the tissues are preserved. The second source is the chemical action between the materials entering the system but not used directly for purposes of nutrition, and in this way the imponderables are rendered free and available for the different functions. Adipose deposits in hybernating animals do not seem to fulfil the intention of keeping them warm during winter, except inasmuch as fat is a bad conductor of heat. The temperature which these animals do maintain above the surround-

ing medium may be attributed to the first effect of oxygen within the lungs or skin, and the gradual deposition of matter within the most important working organs; which matter is transfered to them from others less active in function and daily diminishing in size. Electricity is wanted for the contractile movements of the heart and arteries, and for reinforcing the functions of the nervous centres of involuntary motion. Fat provides this supply; some might jocosely add, that it oils the machinery. Analogy would readily lead us to infer that like the lard of our candles it is eminently fitted for combustion in the strict sense of the term; but several questions may be raised on this every-day process. Nothing can be more easily proved or understood than the fact that heat is directly produced by the solidification or condensation of particles, but it is not quite so evident that the oxidizement of all bodies is attended with the evolution of caloric as a primary or direct result. A burning candle or coal causes light to appear, and this light is a compound of calorific and electrical rays: but let us suppose that the immediate product of chemical combination in some cases is electricity, and that its diverging rays condense the medium of its passage with the evolution of caloric; or let us suppose that other cases result in a compound of greater or of less capacity for caloric; or that it is the rapidity of combination and secondary reactions which complicate the phenomena; or lastly that both imponderables may be liberated one from each of the combining elements. If analogy is dangerous in comparing the properties and functions

of animals and vegetables, it is more so I suspect in comparing the chemico-vital reactions of life with those of the inorganic kingdom. The philosopher of Giessen strains every point to find materials for respiration as if the grand object were to support the function of the lungs instead of considering the functions of the lungs as only one of those which tends to support innervation or animal life. Without doubt damage would ensue to that delicate organ by the action of oxygen upon it, if not duly filled with its normal supply of blood from the right ventricle: for this purpose a sensation of pain would be felt by the unresisting tissues which might be partially and temporarily relieved by a disintegration of the lining membrane, in other words, by a mucopurulent discharge. But the existence of a special sense for the necessity of aeration at once proves that a more important object than that of self-protection is subserved by the lungs. During uterine life the mother's blood already aerated and conveyed through the placenta suffices for the warmth and the nervous excitation of the fœtus, but the first organic movement in the germ is produced by the semen masculinum which imparts to it a nervous character, besides a general power of attracting its pabulum from the surrounding tissues; so that the incipient stage is not due to Caloric but to Electricity which is first alike in date and in importance. When once the vital machinery is put in motion the two forces operate alternately and are developed by composition and decomposition of organic matter. So wedded is Liebig to the assumed origin of animal heat and to

the independent existence of a vital force analogous to other forces with which matter is endowed, that while he distinctly enunciates the cause of nervous force and its strict relation with change of muscular tissue, neither he nor his commentators unequivocally admit the identity of the nervous and vital force. He appears to me to have had a glimpse of what I consider the domain of Truth but was denied the satisfaction of entering therein. Some critics wished to impute to him the charge of confounding the two forces, but he disclaims the paternity of such a sentiment.

PART FOURTH.

The gluten and albumen of seeds are analogous to the pepsin which is formed in the stomach; they are not intended for the nutrition of the young shoots but for their stimulation. By their decomposition Electricity is developed with the effect of enabling the newborn cells to attract metamorphose and fix the carbonaceous matter present, which process necessarily engenders Caloric. Meanwhile the fecula is converted into sugar and other soluble substances, apparently by a loss of Electricity which it sustains during the commotion. It is only during the season of efflorescence or fructification that azotized substances are available for purposes of nutrition: as soon as the young plant has acquired sufficient strength to put out leaves, the necessity no longer exists to the same extent for nitrogen or its compounds; they are consequently expelled in the secretions and excretions. The oil and fecula which is stored in the interior of many trees, like the fat of animals, is destined by its absorption and eremacausis, when the occasion calls for it, to develope free Electricity and thereby aid in keeping alive those functions of the plant which by their suspension would endanger its life: the same use is made of even the heart wood itself at later periods of its existence.

It would be strange if such a disparity exists as alleged between the aliment of vegetables and animals.

Some contend that all vegetables feed exclusively upon inorganic matter of the lowest description, viz, water carbonic acid ammonia and various mineral salts; whereas all animals are said to require the highest order of organized matter. My own observations lead me to believe that neither race subsists upon only one class of aliments. I cannot overlook the necessity which superior plants exhibit during their early growth for semi-organic compounds, such as the fecula o oil of seeds; or forget the facility with which animals of the lowest grade assimilate crude inorganic matter. Compost, whether an original product or the wreck of former growths, is as necessary for the *active* support of the higher specimens of vegetables, as is animal fibrin and gelatin for animals of the most perfect kind. I am aware that fibrin is reduced to the state of albumen before it is absorbed, and it may be argued with propriety that humus is reduced to the state of carbonic acid—but there is too great a resemblance between the humates and the choleates or albuminates of the fixed and volatile alkalies and alkaline earths to reject upon speculative grounds their identity of action upon living cells. The more refined genera cannot afford to waste their energies upon the assimilation of raw materials, but depend for an adequate supply upon others who are the operatives, and are far more numerous and independent. The noble forest oak could not maintain its dignity and distinctive character, did not its roots absorb food already prepared for its wants. So is it with Man; he exacts from other animals the nutritive elements already disposed in a form calculated to en-

rich and strengthen his body without the undue exercise of his digestive faculties. Cellular textures however may be supposed not merely to extract from the blood the more serviceable plastic materials, but actually to create compounds of proteine &c. which do not previously exist: herein acting the part originally assigned by Nature to the whole tribe of cells, that of generating new products or propagating their kind. As in structure so in function the two races of animated beings approach each other. Are cells or fibrous tissues in one race capable of doing what is denied the other? The former may become distended and burst in the effort, but do not the phenomena of life justify us in believing the object one and the same? and where the nidus of an organ is laid in common cellular substance, the deposition of particles to enlarge or repair that organ is still more intelligible. Aliment is taken into the system of the higher animals in two ways: the more consistent and nutritive portion by the lacteals, afterwards still further prepared by the mesenteric glands; the more foreign and liquid by the veins, afterwards subjected to the action of the liver. This latter viscus among its other functions seems to act as an outlet for an excess of venous circulation or congestions of the more important viscera, and also as a sentinel for resisting or questioning liquid contributions from the alimentary canal. The contents of the lacteals correspond with the contents of the lymphatics; they are metamorphosed tissues in a state of solution: moreover the mesenteric glands correspond with the lymphatic glands. But as the venous blood of the body requires to be altered in its

composition before it can again be of essential service to the organs, so the venous blood which forms the portal circle requires a similar ordeal. The lungs and liver are indispensably necessary for this purpose. The nutrition of the small intestines is identical with that of the rest of the body except that in addition to the iron which acts as a vehicle to the carbonic acid of the disintegrated tissues there is a large surplus of soda which takes the choleic acid there formed and conveys it to the liver. The same thing occurs in the stomach; the chlorohydric acid of the hydrated chloride of sodium is there given up, and the soda helps the oxide of iron in carrying away the decomposed tissues. Again; while the chlorine is engaged in its duty of dissolving inorganic matter in the stomach, the atmospheric oxygen by uniting with the pepsin pancreatic and salivary ingredients undertakes to supply Electricity, at the same time that it robs any foreign animal or vegetable matter present of its normal share of the electric fluid, with the effect of altering its composition and partially dissolving it. So that even in the stomach we find traces of what is more apparent in the small intestines, viz: a double mode of alimentation: liquids more especially of an inorganic kind being taken up by the veins and carried to the liver, semi-organic fluids being also taken up by the membrane of the stomach and fixed by the Electricity evolved in that viscus during the reactions before alluded to. The probability however is that the chyme is not sufficiently reduced for assimilation to any extent, when we consider that the vermicular motion is constantly tending to disturb the process

and to urge the contents through the pylorus into the bowels.

The succus nutritivus reaches as far as practicable all portions of the living mass whether animal or vegetable by a common force which consists in an alternate contraction and relaxation of the ultimate vessels and cells. This elasticity in some animals in synchronous with, and partly due to the action of the heart itself. When for instance we pump up water from a well, it is not solely the atmosphere, nor the force applied, nor the partial vacuum, but the elasticity also in a very small degree of the water itself which aids in the process of elevation. Where there is a positive there is also a negative, for a redundancy here implies a deficiency there, in the equilibrium of matter. So when the heart contracts, there is pari passu a dilatation of all the capillaries and cells: this negative condition being caused by the exertion which the heart is called on to make in self-defence. But during its diastole, the electrical tension is instantly transferred to the extreme vessels, and in this way there is a constant centrifugal and centripetal determination of Electricity; the contractility of the vessels being partly due to nerves, that of cellular matter solely to the irritability of organic cells. The passage of matter out from the system leaves an abundance of free Electricity available for the more firm and healthy contraction of the tissues: the fixation of solids and evolution of Caloric expands the tissues for the reception of the vitalizing current which is thus invited onwards. The doctrine of endosmose and exosmose rests on the fact that gases and liquids are condensa-

ble in solid porous substances so that slight causes will dislodge them with facility. Thus when the spongeoles of roots are saturated with moisture which they have absorbed within their meshes, the escape of gaseous excretions from the leaves produces a vacuum which the semi-elastic fluids in the spongeoles are ready to fill. In animals the initiatory act of absorption is strictly analogous, the condensation alluded to being one of the methods devised by Nature to remedy slight deviations from dynamic equilibria. The circulation and organic metamorphoses vary in vegetables and cold-blooded animals at different seasons; in the hot-blooded to a less extent; but there is no reason to believe that the separation of tissues even in these last is so universally extensive as supposed. It is enough for vegetative life that the solids and fluids be subjected to so much change as will impart free Caloric and Electricity to sustain the functions of the more important viscera.

The sum then of my argument is that the final object in vegetables and animals is the same, that of building up their own frame or propagating offsets. The first movement depends upon a temporary redundancy of Electricity or Caloric in matter already organized; after this arises the necessity of fresh materials to sustain the dynamic movements, the introduction of which occurs in two ways. I have claimed an analogy between the leaves or green epidermis of plants and the lungs or skin of animals: also between their roots and the alimentary canal, the soil being their stomach and intestinal tube. Through the former route gases and substances in the state of vapour find

an entrance, by the latter channel liquids and semi-fluid solids are welcomed. This process, wonderful as it appears when considered a vital mystery, is really a more enlarged exhibition of ordinary phenomena. The animal cell will not in general appropriate the same matter as the vegetable cell because their imponderable nature does not correspond—the relation of parts is not identical in the two races, and consequently many of the vegetable products or excretions do not resemble those of animals. I have insisted upon the power of matter to attract matter of the same nature, and to alter or assimilate matters which admit of such change by a metamorphosis of atoms or a commutation of the imponderables. I might add that although products somewhat differing from the parent cell or texture are also formed locally in this way, that other processes of a more general nature may give rise to a variety of compounds which are essential to the welfare of the two races. Indeed the latter is the most probable method of accounting for the nervine of animals, whereas the former perhaps might answer best for fibrin. The nervous filaments merely regarded as conductors of the imponderables may give animals a superiority in this respect; but it is evident from the formation of vegetable organs congeneric with those of animals, that this system cannot be the chief cause of peculiar deposits or molecular arrangements, but a principle common to both kingdoms. Besides, the functions of animal life being more incessant and urgent, a greater loss of materials is experienced by animals than vegetables. In proportion to the change of form will be the available Electricity

and power of attracting and assimilating their aliment, as well as the amount of Caloric liberated, both of which are greatly in favour of animals. I do not deny that carbonic acid is a part of the natural food of vegetables, or choleic acid of animals, but I contend that the substances most conducive to the welfare and perfection of the highest orders in both kingdoms are humus and proteinized matter; that the carbonic acid which is condensed in the soil and dissolved in water is the most abundant and necessary supply of that material. During the day attraction of matter is paramount in plants, and consequently organic transformations are principally in one direction: new substances are deposited with the immediate extrication of oxygen from the superficial layers, but during the absence of the Sun any excess of carbonic acid in the system more than can be used profitably, is restored to the atmosphere together with other effete effluvia. The leaves epidermis and spongeoles give exit to noxious evacuations and superfluous matter, as do the lungs skin large intestines and kidneys.

Let us now examine the ultimate structure of animals and vegetables. We find cells or compound particles of matter highly organized and from their constitutional nature more or less susceptible of transmitting impressions. There are no nerves in the cells of either race, but as nervous filaments of sensation are conveniently disposed in animal textures so as to connect them with central ganglia of motion, there is an additional safeguard in the latter as well as more exalted sensibilities. The organic movements of animals belong to vegetables likewise, but there is a ner-

vous element which distinguishes the hand or tongue from the leaf or flower. Even the fibre of muscles does not essentially differ from the vegetable fibre in organic movement; it is the nerve of motion which imparts to the former its peculiar activity and contractile power. The liver or pancreas independently of the nerves which supply their blood-vessels only represent a more highly organized mass of particles. The lowest class of animals are properly called zoophytes from their bordering on the two races. Animals again are divided into those which possess solely a sympathetic system of nerves which produces involuntary motion, and those which possess a voluntary system of nerves superadded. This distinction perhaps is the broadest and most appropriate.

Writers confess that they are at a loss to account for the descent of the sap—the fact is that the cellular tubes, like the vessels in some of the lower order of animals, determine a centripetal movement, their elasticity producing a vacuum which demands a supply of matter. I do not pretend to decide whether the movement be at long or short intervals; whether it depends upon variations of the barometer and thermometer, or upon a livelier sense inherent in vital tissues; but I hazard the conjecture that the mode of absorption is identical in both races. The cells composing the spongeoles or the leaves of plants have the power of assimilating carbonic acid or analogous compounds, and these substances are deposited in situ as a part of the tissues themselves: from their new settlement they are gradually removed by a transformation of atoms, and received within the sap vessels. Other materials enter

by imbibition and are forwarded by the tubes without further preparation in a manner analogous to venous suction. I need not again refer to the intestinal fixation of the chyme, at least its albuminous constituents; or to its subsequent change of character and passage through the chyliferous ducts, a change attributable to a loss of electricity which the newly-formed tissues sustain under varying circumstances. The soda derived from the bile and which originally aided in rendering the materials more soluble in the intestines, again returns by the route of the portal veins to the liver where it is always ready to officiate. So that the lacteals really afford regular entrance to organized matter alone, the veins of the stomach and bowels being the avenue for other materials. The spleen I regard as a place of deposit for any iron which may exceed the wants of the system: it is here precipitated as an oxide in combination with an electro-negative animal matter which I shall call splenin as it differs somewhat from hæmatosine. When from any cause the heart's action is lessened, and the blood is thereby congested in the great venous trunks, the liver and spleen feel the effects. The indication is to give an impetus to the heart, or a general diffusion of the congested blood to the extreme capillaries by natural or artificial means. Now as soon as the venous trunks connecting with the stomach the liver spleen &c. are engorged to a certain extent, the oppression produced by the stagnating fluids not only provokes a sympathetic action of the heart and perhaps lights up a fever, but the absorbents are also urged to go to work, and take up the splenate of iron which being carried into the

general circulation is decomposed in the lungs and skin: it acts as a tonic, and the prostration is further relieved by the oxygen which enters into a preliminary combination with the iron. The same object may be attained in another way. By nauseating the stomach, the vessels and ultimate cells of the liver are relaxed and permitted to disgorge themselves, and any remains of inflammatory or irritative action is transferred by the bile to the whole tract of the alimentary canal. The bile is a natural purge, as splenin is a natural tonic, or nervous electricity a natural stimulant. Like the choleate of soda in the gall-bladder, the splenate of iron in the spleen or fat in the cellular substance are resources for supporting the functions of the body, not for its immediate nutrition or warmth. The alkalies are evidently useful as vehicles for the introduction and separation of disorganized matters: the alkaline earths are deposited with apparent design, but the metals proper can only contribute collaterally not directly to the welfare of the body. It is probable that many azotized substances in fruits leaves and roots act the same part as splenic acid; that by their means oxygen is absorbed by which organic movements and functional activity are promoted. I have designated the spleen as a reservoir for the blood when not actively engaged in nutrition or functional processes; I might point out other instances of a similar purpose. The thyroid and thymus glands in children seem placed in connection with the lungs and trachea in order to divert the current during uterine life, and also to supply the organs mentioned with additional blood when infantile wants are intimated by long and loud crying.

The same object is fulfilled, although sometimes terminating disastrously, in those who inhabit the gorges of highlands. Their dwellings are in very elevated valleys, and their avocations call them to great eminences. Hence we see the necessity of a provision to enable them to raise their voices and use their lungs in rarefied air; goitres are the consequence, which are handed down as heirlooms to these families isolated as they are from the rest of the world and frequently intermarrying. Can we wonder that so great a tendency of blood to such unnatural excrescences should divert a wholesome activity of function from the brain, and render the Cretan no better than a turkey or a rooster with their gobling and crowing propensities and with analogous appendages in the neighbourhood of their larynx?

It would thus appear that the introduction of oxygen into our lungs is not for the purpose of burning us up piecemeal, as if it were rather a source of evil than of good; for when in accordance with the wants of the economy it is the great agent in supporttng our strength. In hot climates the inhabitants are very wisely indisposed to much exertion, their diet is scanty and consists principally of fruits and rice; whereas in cold regions the natives eat much animal food during their long-continued fishing and hunting excursions: those tribes however whose fare is limited to train oil and lichens in the extreme North are on a parallel with those who near the Equator indulge in the meats and luxuries of cooler latitudes; both are alike the victims of diseases which signalize inappropriate food. It is fortunate that the juicy fruits of intertropical repasts, in comparison with equal weights of the tallow and

blubber of Arctic and Antarctic feasts, contain only 12 per cent of carbon as contrasted with 80 per cent of the same element. But after making allowance for aqueous evaporation, of what use is the combustion of carbonaceous fuel, however little, in a climate the temperature of which is above the normal heat of healthy blood. It surely should not be considered a disadvantage to breathe an atmosphere constituted of even less oxygen in a square foot than is found in the East or West Indies. In fact, the non-azotized food there devoured and decomposed by the oxygen inhaled becomes a substitute for the elements of the body itself in producing the necessary vital contraction: a small proportion however of azotized principles is absolutely requisite to replenish the exhausted state of the muscular and nervous systems under the most favourable circumstances of temperance rest and comfort—in such a climate, where but little energy of body or mind is expected from the natives, vegetable food contributes a sufficiency. It is not a little remarkable that gluten the nutritive element of the Cerealia is most abundant in farina grown between 35 and 45 deg. North and South latitude, precisely in that district of country where the race of men is most perfect, and the equability and amount of the free imponderables most favourable.

Birds of long flight respire freely; their temperature and temperament are consequently above the usual standard of other animals: fishes on the other hand appear to require the oxygen absorbed by water not expressly for heating their bodies but for giving them agility; the aliment which they obtain contribu-

ting but little to their bulk while it facilitates their voluntary movements. An expanded chest is the best point in a horse intended for hard labour. The lungs and liver of young animals are greater in proportion than those of adults: according to the extent of foliage on a tree will be the formation and deposition of woody fibre, and if proper food be supplied the roots, blossoms and fruit will correspond. Power resides in an organ in proportion to its size, its tone in proportion to the imponderables combined with it; the manifestation of this power depends upon the available electricity generated by chemical action in the brain or the organ's corresponding nervous centre. The ferruginous preparations are known to confer benefit not injury to debilitated patients by adding to their store of oxygen; they do not support fever heat but subdue it by imparting tone and vigour to the constitution, provided the alimentary canal still retains its digestive and assimilating faculties. Whether intermittents and other fevers of hot countries be of vegetable or animal origin, whether they arise from organic or inorganic miasmata, or are purely dynamic; whether cancers and certain affections of the lungs stomach and bowels be traceable to animalcules or other malign cause generated within us or around us, it is to the tone of the solids and their power of resistance to which we must look for salvation. For this reason chlorine or iodine when absorbed or liberated from their combinations in the circulation are valuable condiments and medicines for removing such noxious ingredients as may not be amenable to the oxygen of the air, and so far they act as tonics and alteratives:

an excess of either or too rapid an evolution might prove as fatal to the tissues as an overdose of oxygen; but the abuse does not detract from their therapeutical or conservative virtues. This is the case when scurvy breaks out in a crew that has fed too long and too exclusively upon salted provisions; the solids are broken down, and fresh vegetables or acid fruits are reputed the best remedies. During hot weather the vegetable acids refresh us by becoming absorbed with the subsequent production of carbonic acid: electricity thereby invigorates the languishing system not at the expense of the living structures. As they are easily taken up by the veins, particularly after due depletion, and as the living membrane of the small intestines is too weak to digest and assimilate ordinary food, the only alternative left is a recourse to artificial stimuli in order to save the solids and recruit the nervous system. But if these acids be used habitually in excess, the opposite effect is produced; the stomach and bowels become deranged, and free absorption of aliment prevented, at the same time that the vascular and nervous systems are over-excited without additional nutriment or the ability to sustain the action. The neutral mixture or effervescing draught is serviceable in miasmatic fevers; first, they relax the extreme vessels and tissues by a central determination to the stomach, and afterwards they diffuse a wholesome excitement equably throughout the body, so that the organs can execute their offices: this artificial stimulation reduces morbid irritations of particular organs and allays the concomitant distress. The extrication of carbonic acid is not attended with increase of heat

which would be aggravating the case, but is refrigerant and gives tone to the stomach and system generally. Sedatives or stimulants, refrigerants or sudorifics may operate by their own inherent capacities for the dynamic agents; sothat in whatever other way the effects alluded to may be produced, the reduction of compound substances to their simpler or simplest elements cannot but affect us for weal or woe. If during the chemico-vital reactions nitrogren is set free within the capillaries and extreme textures, or if antimony or lead or mercury are reduced from their solutions, can we wonder that tremendous if not fatal effects sometimes ensue from their abuse, while a judicious application of the same might prove beneficial. Like the materials composing meteors, they have been taken up under circumstances which perhaps no longer exist —they are e situ naturali, and by their precipitation engross much free electricity which becomes latent and withdrawn from active service.

Non-nitrogenized food does not provide so much free Electricity as nitrogenized compounds in which carbon and hydrogen are condensed; and consequently the former is better adapted for certain states and stages of disease which could not tolerate much excitement of any function: but during convalescence nitrogenized food is especially indicated to give tone to the nervous system and to rebuild the dilapidated frame. Now both jellies and good wheaten bread are recommended as precursors to meat in moderate quantity with decided advantage. Those aliments in which sulphur phosphorus and lime exist offer the readiest means of reparation for certain tissues of the body

most essential to health. It is on account of the nitrogen present in many medicines that they are so eminently useful in aiding the natural efforts, for by their eremacausis (or perhaps metamorphosis) a genial flow of Electricity is every where diffused, and a tonic effect is very obvious. Alcohol is serviceable in particular exigencies as a stimulant, when no fixed organic lesion, as of the brain, would be likely to attract its especial influence. The man who is addicted to the use of ardent spirits craves the indulgence of his appetite not for the warmth which the alcohol affords, this he can supply by clothing and artificial heat, but for the Electricity which is liberated first in his stomach to a small extent, and afterwards in the circulation. If alcoholic beverages be taken by a healthy person moderately and at proper seasons, during its decomposition in the blood nervous excitement results, and carbonic acid or some carbonaceous products are eliminated from the lungs &c. in a quantity corresponding with the draught and the elevation of spirits: but if the same amount be taken upon an empty stomach so as to operate locally and prejudicially upon that viscus, particularly if the subject be very irritable or in bad health, the local action prevails over a general tendency to excitement, and the spirits are depressed with corresponding diminution of carbon in the secretions or excretions. There is a point beyond which the introduction of stimulants or tonics is prejudicial. As soon as the brain loses its control over the voluntary functions, so that the Electricity developed by the constituents of the blood instead of being available for special purposes of the will is engaged

in fomenting local irritation upon the lining membrane of the heart and arteries, there is necessarily a sense of prostration or inability to stand erect, notwithstanding a fullness and frequency of the pulse. A current of blood excited by ardent spirits rioting through the veins is no more manageable than a mill-stream which overflows its banks during a freshet—there is force, but it is not applicable to useful purposes. Besides, we must not forget that any form of matter in which carbon enters, if the oxygen introduced be insufficient to combine with it, depresses the system by its presence, as every thing that is not in harmony with the wants or the particular state of the system is against it. There can be no neutrality in such matters; Caloric and Electricity if they are not directly or indirectly useful are directly or indirectly injurious. Water and organic elements in which oxygen and hydrogen are in the proportion to form water are not remarkable for their electro-positive or negative qualities, but they become indispensable for this very evenness of character which admits of such extensive but gradual application. The primary products however of all carbonaceous matters may pass away without being entirely converted into carbonic acid and water; for we find that, when oxygen is deficient, the breath betrays an indiscreet indulgence in either solid or liquid food which but for this outlet and others as the liver kidneys skin and large intestines would incommode rather than promote the due performance of the functions of life.

I have often reflected on the virtues ascribed by the Russians and some Medical Practitioners in Germany

and the United States to the vapour bath. That the effect produced in disease is momentous no one will deny; and it ought therefore, like many other remedies, to be cautiously administered, and with a full knowledge of its possible consequences. But one thing is certain, that during a comparative state of health, it tends to maintain the blood in its purity by a free and perhaps vicarious purgation of any noxious ingredients or an excess of materials in the circulation: it also equalizes the nervous fluid and consequently discusses any tendency to local determinations. This condition of bienêtre is co-extensive with the sentient surfaces and textures of the body, and intoxicates as it were the brain with an indescribable satisfaction which terminates in as indescribable a relaxation of mind and body. It is an artificial mode of raising moderately the pulse and the functions. We must under the circumstances conclude that, setting aside any direct influence of the imponderables according to the temperature and temperament of baths in general, the chemico-vital actions which supervene are mainly at the expense of the materials composing the body, since it is evident that no additional amount of oxygen is introduced, or an increase of diet tolerated in most cases. There is rather a sortie of Disease than an entrée of Health—a relief from oppression which tranquillizes the feelings rather than a gratuity of strength and vigour imparted. The exhilaration consequent upon the unnatural developement of Electricity in the system should not be continued so far as to render the subsequent depression excessive, unless this effect is desired for particular purposes. It is only

when luxuriously or inordinately applied that even tobacco or wine may be said to injure us, or any other moderate enjoyment whether nutritive or stimulant. A judicious use of the bath gives a greater security against colds or inflammations: but when the relaxation is over-great there is of course less resistance offered to all depressing agencies. Of the two extremes which one meets in Northern countries, an excessive use of hot vapour baths or an excessive abstinence from every thing calculated to open the pores of the skin, in other words, excessive uncleanness, who would hesitate to make the choice? If the former produces premature debility and nervous complaints, the latter produces typhus and a long list of putrid fevers to be traced to sanguine impurities.

The free Caloric of health is due to the deposition of fresh solid materials in nutrition, or the greater consistency given to the blood by the formation of fibrin; whereas free Electricity results from an opposite state of things, viz, the disintegration of tissues or the return of blood from arterial to a venous condition. It is obvious that during childhood more matter is laid down than taken up; that the tissues are succulent, and animal heat exuberant—during old age more matter is taken up than laid down; the tissues become stiff and more solidified while animal heat is at the minimum. But during manhood both heat and physical power is at the maximum. The exaggerated heat in disease is more apparent than real; the sensibilities of the nervous expansions and of their ganglia are temporarily augmented by venous congestion behind, and an arterial determination in front; the vital move-

ments may be quicker and in the earlier stage more laborious, but the general tone and nervous power diminishes as local draughts are made upon its stock, whether for functional purposes as by the heart in fevers, or for the reparation of organic lesions during the inflammatory process. The engorgement of the great venous trunks connected with the venæ cavæ, and a relaxation in the heart's accustomed energy necessarily cause a regurgitation of the venous blood upon the nervous centres—they are thereby irritated and goaded, more particularly the cardiac plexus, to feverish action. Their functions are whipped up for the occasion, to sink with greater rapidity, if the object for which they were excited be not attained.

"Ubi irritatio ibi fluxus" is an old saying deduced from observation and experience; but its strict application in Science must be modified in accordance with improved means of diagnosis. At the present day "ubi irritatio ibi congestio" perhaps might answer as well; but in fact the term irritatio admits of too great latitude. A vital cell, tissue, or vessel, whether raised or lowered beyond the normal extent of its dynamic habitudes, is the recipient of a larger amount of the circulating fluid: for instance, let the liver be positively excited by Electricity either generated in the organ itself by matter absorbed from the alimentary canal, or concentrated upon it from sympathetic relation with other organs or tissues, and there follows an increased action of the arterial capillaries with superabundance of red blood. But let us suppose the liver to be negatively affected in some way, and there arises a venous turgescence or congestion a tergo which

would obstinately remain until the malaise occasioned by over-distension should at length awaken the dormant sensibility of the part and an electrical movement in the sympathetic ganglion connected with it. The synergies are now brought into requisition, and the heart at length responding to the call not only helps to unload the distressed viscus by pumping out the contents and creating a diversion in the dermoid and other textures, but sends arterialized blood to the rescue of the liver itself, so as to give new tone and vigour to the tissues and vessels engaged. Should however the effort fail, should the fluxus be incompetent to do good, it does harm by lighting up perhaps active inflammation with various sequelæ in addition to the general fever. The object then of the physician in his recourse to venesection is two-fold—while he recognizes the necessity of reaction both general and local, which is accomplished by the proper condition and amount of the blood, he cautiously reduces, either before or after the expected crisis, its absolute amount so far as it oppresses the heart and other viscera: also while the absorbents are introducing a fresh supply of watery serum, he dilutes and qualifies still further the current by cooling drinks to prevent its excessive action upon diseased or weakened tissues. By the abstraction of blood the red globules are not allowed to concentrate their force upon any one particular part, but are diffused generally to the evident relief of any morbid portion which could ill resist the energy of its accustomed share of oxygen, much less a well-meant but unfortunate determination of the same upon it. A restricted diet of a mixed character

does not add much to the volume of the circulation, but offers sufficient pabulum for the oxygen inhaled and the gradual restoration of the wasted frame without detriment to the living tissues themselves. Purulent secretion I regard as the result of a provisionary vital movement in cellular membranes and tissues by which they are saved from further corrosion at the expense of materials which are drawn from other quarters, and concocted in a form suitable to protect the exposed parts from the external air; whilst its composition is such as to divert and engross the superabundant Caloric and Electricity there engendered. It may however be contemplated as a more rapid rejection of abortive cells by serous and mucous membranes which are unable to assimilate the vast amount of albuminous matter brought to them by the excited capillaries, and which the absorbents are unwilling to take back by reason of vascular plethora. As respects internal abscesses the secretion continues while there is an intermission of tonic rigidity in the surrounding parts and system generally; so that as soon as reaction is restored, the matter deposited is compressed and in its turn presses upon the most yielding portion of the walls, where an external opening is effected for its escape. Inflammation like fever is a restorative process, at least this is its intention; for the increased nervous action first set up is to support if possible further engorgement. Local stimulants and bandages are applied for a similar purpose—these would be positively deleterious during the height of the reaction, but at the incipient stage or at the decline artificial support is alike demanded.

The different organs of the brain increase in size and energy by proper exercise: they acquire constant additions to their mass in accordance with the force and direction given to the arterial current; but when abused by voluntary or involuntary excess their vigour declines owing to a gradual absorption of substance and their incapacity to appropriate fresh materials. This is a chronic departure from health; in acute cases, either the chemico-vital reactions developed in the capillaries excite the organ or organs to derangement of function, or the oxygen makes an attack upon the cerebral tissue itself. Inflammation of the brain proper attended with maniacal symptoms would be an exaggeration or morbid manifestation of the process. I may here repeat that the term oxidizement is by no means synonymous with combustion, unless every chemico-vital movement of oxygen be so regarded. I can recognize nothing more familiar or more strictly chemical in the disposition of oxygen to destroy than to construct certain forms of matter. Oxygen is as often employed I presume in the one case as in the other, and both phenomena are determined by the accidental relation of the elements at particular conjunctures. We should remember that it is not gaseous oxygen which operates in the changes alluded to, but oxygen in an altered condition. After the combination of the atmospheric oxygen with the red corpuscles of the blood, it becomes liquid with the evolution perhaps of slight sensible heat; even here it is not the gas in its elastic state as just received through the bronchial tubes to which I refer, but that which has already become condensed in the tissue of the air-cells. During the conversion of the quasi-solid carbon of the

tissues and blood into a solution of the protocarbonate of iron, the reverse of heat is more probable. The consolidation of living structures is the ne plus ultra of formative power, and a change of consistency in semi-organized matter may be distinctly traced both towards the goal of Life and in an opposite direction.

In persons of a lymphatic constitution the transformation of albumen into fibrin is but partially attained, and cellular substance in excess distinguishes them from others in whom the digestive and respiratory processes are more complete. Those who possess the nervous and sanguine systems large and well-balanced, in short the essential requisites of health, present the most perfect developement of form and functional activity. The tissues of the one are loose, those of the other firm and elastic; their diseases are also characteristic, as are those of the purely sanguine and purely nervous constitutions in which the blood vessels or the nerves predominate to an extent incompatible with each other's rights and duties. I have no where seen a clear discrimination made between the physiological traits of the herbivorous class of animals and the carnivorous. The latter unquestionably exhibit more of the nervous temperament, their sensations are more acute and their movements more rapid; but exhaustion soon overtakes them from the draughts made upon their own substance when adequate food is not within their reach. In herbivorous animals the supply of free nervous force is principally derived from an abundant ingestion of non-azotized food and depositesof their own fat, which last longer and are more serviceable for continued labour and patient endu-

rance. Those animals which consume a mixed diet present a mixed constitution and character. The same rough distinction may be drawn between different classes of vegetables which, I have no doubt, owe their peculiar properties to peculiarities of diet, modified as in the case of animals by climate which prompts them to select their materia alimentaria. The delicate and sensitive flowering plants of intertropical latitudes as we find them in our gardens and hot-houses may be justly compared to the refined and high-toned specimens of mammalia which adorn the most civilized communities.

The inference to be deduced from late experiments with the gaseous voltaic battery is this; that the oxidizement of a metallic series may increase but does not originate the current. It depends upon the electrical capacity of the newly-formed oxide, and its relation to other contiguous substances whether any electricity or how much is set free. If when oxygen combines with hydrogen to form water electricity is developed, that portion at least which is available for the inductive state may not be a direct result of the combustion but of the change of form: so respiration produces electricity when the carbonate of iron assumes the state of the hydrated peroxide. It is inconsistent with the laws of animal life that gases such as hydrogen, the olefiant, carbonic oxide, or even carbonic acid, should become free and allowed to circulate within us. I regard Liebig's hypothesis of the absorption of nitrogen from the stomach as one of the weakest points in his argument; likewise the supposed entrance of the sulphide of hydrogen from the lower bowels as totally

unfounded in fact. Blood removed from the body and no longer under the vital influence may absorb free gases or eliminate them ready-formed, but this is not the question at issue. Liebig's treatise in the main demonstrates the probability of a radical difference between organic and inorganic metamorphoses and reactions; the former being confined to changes of no violent character, but to the production of compounds which still retain a comparatively high equivalent number; whereas the latter are generally split up into more elementary and less complicated relations.

Such is Life and such its manifestations—what is Death but a gradual decay of the organs and consequent debility of their function. In ordinary language the digestive organs become less succulent, and absorption more difficult; the waste and supply no longer correspond; a demand is made which cannot be answered: less free caloric and electricity are consequently developed by chemico-vital reactions—a flaw perhaps now appears in the machinery, and there is a sudden pause in its movements.—

Whether the operations of the mind are to be considered as functions of the brain analogous but superior to those of other organs, and whether human actions should be regarded as results of physical organization, I leave my readers to judge for themselves according to the evidence presented to their senses, and the light which reason affords.